SCIENCE ABSTRACTS.

Section A.—PHYSICS.

JANUARY 1915.

GENERAL PHYSICS.

1. *Condensed Azimuth Tables.* **G. W. Littlehales.** (Washington Acad. Sci., Journ. 4. pp. 461–467, Oct. 4, 1914.)—Finding the azimuth may be regarded as a terrestrial measurement in connection with which the observed celestial body is considered to be projected vertically downward on the surface of the earth, taking the azimuth angle as that whose apex is formed at the geographical position of the observer between his meridian and the great circle passing through his position and that of the celestial body. Then since every great circle of the earth, except the equator itself, crosses the equator, there is always a point on the equator whose azimuth or true bearing from the observer is the same as the azimuth of the observed celestial body. The recognition of this relation permits the condensation of existing tables of azimuth, by omitting all except that relating to 0° declination. It is only necessary to provide convenient means for finding the difference of longitude or hour angle between the meridian of the observer and the meridian of the point of intersection with the equator of the great-circle arc passing through the geographical positions of the celestial body and the observer. The abridged azimuth tables are entered with this difference of hour angle and the latitude of the observer, and are given for latitudes 0° to 61°, arranged for use with the gonomonic projection charts issued by the Hydrographic Office. C. P. B.

2. *Stress Distribution in Short Compression Members.* **E. G. Coker** and **L. N. G. Filon.** (Engineering, 98. p. 542, Oct. 30, 1914. Paper read before the British Assoc., Australia, 1914. Chem. News, 110. pp. 121–125, Sept. 11, 1914.)—Describes experiments with a new form of testing machine in which different materials were used for the pressure plates. It was found that with brass plates the stress was much smaller at the plane of separation than at the centre of the block, there being a considerable end effect tending to reduce the compression stress at the end faces, as the brass prevented the free lateral displacement of the loaded material. The stress distribution changed considerably when a thin sheet of india-rubber was interposed, and

uniform stress conditions were secured by the use of an intermediate layer of the material under test. Hence it was concluded that in compression tests the load should be applied through an intermediate layer of the same material and not through hard-steel face-plates. J. W. T. W.

3. *Crushing Strength of Ice.* **H. T. Barnes.** (Roy. Soc. Canada, Trans. 8. Ser. 3. pp. 19–22, 1914.)—Describes experiments on the ultimate crushing stress of blocks of clear river ice. The blocks were placed in a hydraulic press so that their axes were sometimes parallel, sometimes perpendicular, to the direction of pressure. The crushing strength was sensibly the same in both cases, but in the former the ice burst sideways into innumerable long needles, falling to pieces on removal from the press, whereas when the pressure was applied perpendicular to the axis of the block the latter cracked lengthwise or transversely, without shattering. The mean ultimate strength was found to be 363 lbs. per sq. in., at a temperature of about 0° C., although the first signs of cracking appeared at about half this stress. J. W. T. W.

4. *Expansive Force of Ice.* **H. T. Barnes, J. W. Hayward, and N. M. McLeod.** (Roy. Soc. Canada, Trans. 8. Ser. 3. pp. 29–49, 1914.)—Treats of several questions connected with the study of the thrust exerted by ice on dam-walls and similar structures. A full account is given of the observations of W. H. Sawyer on the formation of "reefs" or "wrinkles" on the surface of a frozen lake owing to the expansion or contraction of the ice-sheet. His experiments on the coefficient of expansion of a long bar of ice showed that this coefficient had a max. value at the freezing-point and then decreased, rapidly at first, but only slowly below 0° F. The average coefficient between —20° and + 32° F. was 0·0000284, giving 3·75 ft. for the total expansion, due to a rise in temperature of 50 deg. F. of a sheet of ice a mile long. His conclusions as to the provision to be made on this account in the construction of dams for reservoirs under various conditions are also quoted. A full account is then given of observations by the authors on the behaviour of cracks in the ice-sheet of a filtration chamber. When the temperature rose above the freezing-point these cracks closed, but a succeeding hard frost opened a new system of fresh ones similar to them. All these cracks were observed to be wedge-shaped, ending before the under-surface of the ice was reached. This showed that there was unequal contraction from the surface downwards. The breadth of the cracks seemed to bear a close relation to the temperature. It was also observed that similar cracks seemed to have been

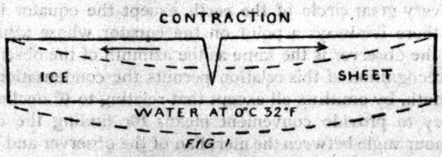


FIG 1

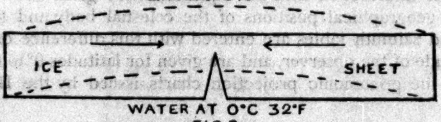


FIG 2

formed on the underside of the ice extending roughly half-way through the sheet. The temperature of the water beneath the ice was found to vary from 0° C. at the ice-surface to between 1·8° and 3·4° C. at the bottom of the reservoir. The thickness of the ice was also measured in different positions and was found gradually to increase everywhere throughout the period of experiment (Feb. 17–March 24, 1914).

A theory of ice cracks is propounded, and from this it is concluded that any large sheet of ice will buckle and bend before the ultimate crushing strength of the ice is reached. For, owing to the fact that the under surface of the ice cannot ever differ much from the freezing-point, no expansion or contraction takes place at this surface. Fall of air temperature will, however, bring about a contraction of the upper surface, thus causing the sheet to bend downwards and the ice to crack as represented in Fig. 1. So long as these cracks remain open they will take up the thrust of the ice when the temperature rises. In general, however, they are filled up with snow or water, so that ultimately the cracks are frozen solid and the whole sheet is cemented into a firm mass. When a rise of temperature occurs, the cracks will now be from below as in Fig. 2, and will of course at once fill with water and freeze, so that in this way a "creeping" action takes place tending to expand the ice-sheet, and from this cause a permanent thrust will result. Assuming the crushing strength of ice to be 400 lbs. per sq. in. [see preceding Abstract], the limiting thrust is deduced for various thicknesses of ice. An extensive account is then given of experiments by G. G. Bell, who found the tensile strength of ice to be 120 lbs. per sq. in. The same author stated, further, that if the ice were firmly frozen to a concrete surface it would develop its full crushing strength, irrespective of the inclination of the line of ice to the surface of the concrete, provided the temperature were below the freezing-point. J. W. T. W.

5. *Filtration Coefficient of Fine-grained Homogeneous Sands : Extension of the Method to Heterogeneous Sand.* **J. Boussinesq.** (Comptes Rendus, 159. pp. 584–586, Oct. 5, 1914.)—In the previous paper [Abstract No. 1945 (1914)] limiting assumptions were made so as to evolve a theory consonant with experiment. This theory is now extended to meet the actual case of heterogeneous sands, whereas previously homogeneity alone was considered. In the latter case $1/\mu$ (μ being the filtration coefficient) is proportional to $(2R)^2$, where 2R is the diameter, per unit of driving force I. For a heterogeneous sand, the most simple hypothesis to adopt is the arithmetic mean of the squares of the two extreme diameters as the average square of the diameter. With this modification the previous theory is then found to apply to the more general case of heterogeneous sand, and the note concludes with a discussion of the amended formulæ. H. H. Ho.

6. *Relativity Theory and General Dynamical Principles.* **R. C. Tolman.** (Phil. Mag. 28. pp. 572–582, Oct., 1914.)—The author here continues the formulation [see Abstract No. 548 (1913)] of consequences of a system of mechanics founded upon: (1) Newton's Laws of Motion with the substitution of rate of change of momentum for mass-acceleration, these not being identical when, as in the relativity theory, the mass varies with the velocity; (2) The Conservation of Mass; (3) The Einstein transformation equations for co-ordinate systems in relative motion. The Conservation of Momentum is first derived from the fundamental equation of motion. An equation for the Conservation of the Moment of Momentum of an isolated system is next

obtained. An expression is then found for the kinetic energy of a system of particles, and the reason shown of its present unsuitability for use in defining the Lagrangian function, in that the derivative with respect to the velocity of the kinetic energy of a particle is no longer, as in the Newtonian mechanics, equal to its momentum. A suitable quantity to replace the kinetic energy in the Lagrangian function is then introduced, and a modified expression of the principle of Least Action shown to hold good. Equations corresponding to Lagrange's equations in Newtonian mechanics are then obtained, differing from them only in the definition of the Lagrangian function. The equations of motion are finally derived in the Hamiltonian or canonical form, and employed to deduce the principle of the Conservation of Energy.

G. W. DE T.

7. *Relativity Theory and the Equipartition Law in a System of Particles.* **R. C. Tolman.** (Phil. Mag. 28. pp. 583–600, Oct., 1914.)—The principle of relativity necessitates a revision of the kinetic theory of gases. F. Jüttner has derived a modified form of the Maxwell distribution law for the momenta of molecules of an ideal monatomic gas in which all the molecules have the same mass [Abstract No. 848 (1911)]. The author here considers systems containing particles of different masses. Starting with the Hamiltonian equations already derived [see preceding Abstract], the system is defined by n generalised co-ordinates and the corresponding momenta, and the state of the system at any instant considered as determined by the position of a point plotted in a generalised space of $2n$ dimensions. Liouville's theorem of Newtonian mechanics, that a distribution originally of uniform density will remain uniform is shown to hold. The energy is first expressed as a function of the momentum, and then a law of distribution corresponding to the equipartition law of Newtonian mechanics is obtained, and leads to the conclusion that, where v is the velocity of a particle divided by the velocity of light, the average value of $m_0v^2/(1-v^2)^{1/2}$ is the same for particles of all different masses. This equipartition is found to be true not only for a mixture of particles of different masses, but also for systems of particles which are separated by a partition that allows transfer of energy. Hence the equality of the average values of this quantity becomes the relativity condition for thermal equilibrium, and the quantity is further shown to be proportional to the absolute temperature as measured on the thermodynamic scale, so that in all such considerations this new quantity satisfies the same relations as the *vis viva*, m_0v^2, of Newtonian mechanics, and indeed reduces to that quantity when the velocities are small compared with that of light. It is to be noted, however, that the quantity $m_0v^2/(1-v^2)^{1/2}$ is neither the relativity expression for the total energy of a particle of mass $m_0/(1-v^2)^{1/2}$ nor for the kinetic energy $m_0/(1-v^2)^{1/2}-m_0$, and hence in relativity mechanics there can be no possibility of an exact equipartition of energy. The fact that the equality of the average values of $m_0v^2/(1-v^2)^{1/2}$ is the necessary condition for equality of temperature has the very important corollary that for any given system of particles at a definite temperature the distribution of momenta, and hence the total energy-content, is independent of the volume. An interesting result is obtained by comparing the expression for the total energy, $E=3nRT$, of n gas molecules of negligible masses with the corresponding expression of Newton's mechanics, $E=\frac{3}{2}nRT$, which undoubtedly holds when the masses are sufficiently large and the velocities sufficiently small, showing that for particles of very small mass the average kinetic energy at any temperature is twice as large as that for large particles at the same temperature. It appears that at all ordinary temperatures we may expect the equipartition law to be substantially exact for particles of masses not less than the mass of the electron. G. W. DE T.

8. *Figures of Equilibrium of Rotating Fluid under the Restriction that the Figure is to be a Surface of Revolution.* **J. R. Wilton.** (Phil. Mag. 28. pp. 671–685, Nov., 1914.)—Mathematical.

9. *Similar Systems and Dimensional Equations.* **E. Buckingham.** (Phys. Rev. 4. Ser. 2. pp. 345–376, Oct., 1914.)—Discusses the most general form of physical equations by means of dimensional relations, and then applies the results to physically similar systems. A convenient summary of the general consequences of the principle of dimensional homogeneity consists in the statement that any equation which describes completely a relation subsisting among a number of physical quantities of an equal or smaller number of different kinds, is reducible to the form $\psi(\Pi_1, \Pi_2, \dots \text{etc.}) = 0$, in which the Π's are all the independent dimensional products of the forms Q_1^x, Q_2^y, ... etc., that can be made by using the symbols of all the quantities Q.

While this theorem appears rather non-committal, it is claimed to be a powerful tool and comparable, in this regard, to the methods of thermodynamics or Lagrange's method of generalised co-ordinates. E. H. B.

10. *Temperature Coefficients of the Free Surface Energy of Liquids at Temperatures between* −80° *and* 1650°. VIII. *Specific Surface Energy of Salts of the Alkali Metals.* **F. M. Jaeger.** (Konink. Akad. Wetensch. Amsterdam, Proc. 17. pp. 571–584, Nov. 7, 1914.)—Measurements similar to those previously made on the halogen salts of the alkali metals [see Abstract No. 1948 (1914)] have been carried out with lithium, sodium, potassium, rubidium, and caesium sulphates and nitrates; lithium, sodium, and potassium metaborates, and sodium and potassium molybdates, tungstates and metaphosphates. The melting-points and the values of a, b, and c are given for each of these salts. Although, for corresponding salts, at one and the same temperature, the value of χ_t appears gradually to decrease with increase of the atomic weight of the alkali metal, lithium nitrate forms an exception to this rule. In the series of the alkali nitrates, other abnormalities also occur, for example, with the solubilities and melting-points. No simple relations are found among the values of the temperature coefficients, b. T. H. P.

11. *Capillarity of Liquid Hydrogen.* **H. K. Onnes** and **H. A. Kuypers.** (Konink. Akad. Wetensch. Amsterdam, Proc. 17. pp. 528–532, Nov. 7, 1914. Communication No. 142*d* from the Phys. Lab., Leiden.)—The determination of the capillary constant of liquid hydrogen in contact with its saturated vapour was made by the method of capillary rise. The reading of the height of the column in the capillary tube was made by a cathetometer. The surface tension of liquid hydrogen in dynes/cm. as observed, varied from 2·12 at 20·40° K. to 3·18 at 14·66° K. The constant as a function of T is nearly a straight line. J. J. S.

12. *Relation between Velocity of the Gradient Wind and that of the Observed Wind.* **J. Fairgrieve.** (Meteorological Office, Geophys. Mem. No. 9. pp. 189–207, 1914.)—In the preface W. N. Shaw gives a history of the evolution of the idea of "gradient" wind, that is, the wind theoretically deduced

from the pressure distribution, and an account of the practical use which is now made of this quantity. The surface wind as recorded by anemometers is dependent to so great a degree upon local conditions of exposure that the gradient wind forms for many purposes a more suitable standard of reference. Tables are given in the preface of the extreme wind-pressures recorded on a pressure plate at Holyhead, of the extreme pressure gradients which have been measured on the working charts of the Meteorological Office, and of the extreme velocities recorded at various anemograph stations. In the paper the author points out that Guilbert, in his well-known system of weather forecasting, places great weight upon the "normal" wind, which he considers the same, for any given gradient, at every observing station and for winds from all directions. The paper was drawn up with a view to obtaining some more satisfactory values for this "normal" wind than those assumed by Guilbert. Five British stations which report to the Daily Weather Report are dealt with, and for each a table has been prepared which gives the value of the gradient wind at the time of the morning observation, together with the direction and force (on the Beaufort scale) of the observed wind, for each day. The 12 years 1901–1912 have been dealt with. Owing to several sources of uncertainty in the data, and possibly also to causes which may be termed meteorological, many different Beaufort numbers are represented in the tabulated results against each individual value of the gradient wind. This leads to uncertainty as to the best method of determining the relation between the estimated and the gradient wind, and three different methods are put forward by the author: (1) By drawing a smooth curve through those estimated forces which occur most frequently with the individual gradient velocities; (2) by taking the average of all the Beaufort numbers corresponding with each gradient velocity; and (3) by averaging the gradient velocities corresponding with each Beaufort number. The features of each method are discussed, and it is concluded that the values of the average Beaufort numbers given by method 2 corresponding with gradient winds of 10 to 14 m./sec. are likely to be accurate within narrow limits. This method has been employed in determining the relation between the observed to the gradient wind for different directions. For determining the relation for different velocities, however, method 1 is considered most suitable. The values are represented by diagrams, and in discussing the results it is found that the value of the "normal" wind, which Guilbert assumes at about 45 % of the gradient for all cases, varies from 81 % for Holyhead with N. winds to 11 % for St. James' Park, London, with SE. winds. From the whole investigation the following conclusions are put forward tentatively:—(1) North-easterly winds are normally nearer the gradient velocity than others. (2) If winds come over a large expanse of water they are nearer the gradient velocity than if they come over land, notwithstanding local conditions; and (3) local conditions, *i.e.* exposure, may serve to modify to some extent the strength of the wind. J. S. Di.

13. *The Effect of the Labrador Current upon the Surface Temperature of the North Atlantic: and of the Latter upon Air Temperature and Pressure over the British Isles.* **M. W. C. Hepworth.** (Meteorological Office, Geophys. Mem. No. 10. pp. 211–220, 1914.)—The paper forms a continuation of an earlier work which dealt with the five years 1903–1907 [see Abstract No. 1494 (1912)]. The five succeeding years 1908–1912 are here examined and notes are given of the ice conditions and sea temperatures in the North Atlantic, and of the air temperature and pressure at certain selected stations in Great Britain, for the individual years. These data with corresponding mean temperature values are also represented by diagrams. The author forms the opinion that if in connection with long-period weather forecasts for the British Isles sea-surface temperature data be used at any future time, it will be necessary that a larger number of reliable observations be available for all parts of the North Atlantic than are at present obtainable. J. S. Di.

14. *Water and Volcanic Activity.* **A. L. Day** and **E. S. Shepherd.** (Geolog. Soc. of America, Bull. 24. pp. 573–606, Dec. 16, 1913.)—The present paper contains a record of studies of which the purpose was to obtain definite information about the character of the chemical reactions which take place in an active volcano, and in particular to determine the rôle played by the gaseous components, which are very important factors in both its chemical and physical activities. In many previous studies of volcanoes the gases have been allowed to escape entirely, while in others they were not captured until the nature of the components was so much altered by oxidation or otherwise that their identification, relative proportions, and the character of the equilibrium existing between them, has remained uncertain. Previous observations published by Green in 1887 and Brun in 1911, led these authors to conclude that the Kilauea emanation is anhydrous, although students of vulcanism generally have concluded that water is usually, if not always, the chief agent in volcanic activity. The observations of Green and Brun are discussed at great length, and the opinion expressed that they offer no proof of absence of water-vapour in volcanic exhalation. An explanation of the volcanic cloud makes finely-divided sulphur responsible for its presence and not crystalline chlorides as supposed by Brun, since only a minute quantity of chlorine or its salts could be detected in the emanations. Brun's hygrometric observations are discounted by the circumstance that sulphur dioxide and trioxide, present in large quantities in the exhalations, are most effective drying agents, and the effect of charging air with even a small quantity of sulphur dioxide has been tested by dew-point observations in the laboratory and afforded most convincing results. Successful attempts to collect the volcanic gases before reaching the air are next described in detail. The results of a chemical study of the material collected are given, including analyses of the lava and different methods of examining the gases. An iron collecting tube had to be used for collecting the gases, since, owing to the high temperature and the splashing of the molten lava, neither glass nor porcelain would have withstood the ordeal, and a silica tube was not available. As this iron pipe was partly destroyed by the joint action of the sulphur and sulphur dioxide, the authors have considered at some length the effect of this on the relations between the gases collected, and conclude that the presence of iron can have no considerable significance. The reactions between hydrogen, sulphur dioxide and carbon dioxide next receive attention, since at temperatures in the vicinity of 1000° interaction must take place, and it follows directly from this that the chemical analyses of volcano gases offered by Brun in support of his conclusion that the exhalations from Kilauea and other volcanoes are anhydrous, also contain the clear proof that his conclusion is untenable. In so far as their reconnaissance yields final results, the authors conclude that the gases evolved from the hot lava at the Halemaumau crater are N_2, H_2O, CO_2, CO, SO_2, free H, and free S, with Cl, F, and perhaps NH_3, in comparatively insignificant quantity. No argon or other rare gases and no hydrocarbons were found. The first conclusion to be drawn from such a

gaseous association at 1000° is that no equilibrium can be possible, and that chemical action between the gases is still going on when discharged into the air. Free sulphur, for example, could not have remained in permanently stable association with CO_2, nor free hydrogen with CO_2 and SO_2 at 1000°. Two consequences follow from the continued expansion of the gases, which are thermally opposite in sense. First, the rapid expansion is a cooling process, and may well be the sufficient cause of certain lava formations in which great blocks appear to have cooled so rapidly throughout their mass as to remain discrete blocks of the roughest and most ragged outline. The second consequence of the gradual release of gases is the interaction between the gases thus set free in constantly increasing quantity as the surface is approached. These reactions are accompanied by evolution of heat, operating to raise the temperature of the surrounding lava so long as the reacting gases remain in contact with it. The heat generated by these gases reactions, in the region near the surface where the amount of gas is large, may be more than sufficient to counteract the cooling effect of the expansion within the rising lava column, which may thus become hotter, and not cooler, as it approaches the surface. A theoretical discussion of this question serves to show that there is no cooling effect of comparable magnitude with the heating effect of the reactions going on within the active lava. Successive tubes collected from the volcano at the same time do not show the individual gases to be present in the same proportions, but in such proportions as change with every bubble bursting from the liquid basin. This absence of equilibrium and consequent variability of composition is also in accord with the observations of Perret and others at Vesuvius, that the relative proportions of the gases vary greatly with the condition of the crater. From this standpoint the laboratory observations of Brun on "live" or "explosive" lavas as opposed to "dead" lavas acquire new and rational significance, for if lavas may be regarded as carrying gases in solution or mechanical imprisonment which may react with evolution of heat the moment they are free to do so, the term "explosive" lava acquires a new and definite meaning. If, on the other hand, the gases were in equilibrium with each other throughout the solidification period, then reheating lavas in the laboratory could discover no "explosive" rocks. To the contention of those who support the anhydrous emanation theory that the basic minerals give no indications of having been in contact with water, highly susceptible as they are to such an influence, the authors point out that in the absence of oxygen no chemical change could be detected between powdered lava and water at 1100°. The authors finally discuss the problem of the origin of the water, since this must be present as an active ingredient of the liquid lava in view of the positive character of the evidence offered. Three possibilities are considered: (1) That water may have entered by infiltration of sea-water from the surrounding ocean, or (2) through more or less deep-seated infiltration of water originally meteoric, or (3) that it may be strictly magmatic in character and an original constituent of the lava.

The authors conclude from such evidence as is available, that the water released from the liquid lava when it reaches the surface is entitled to be considered an original component of the lava with as much right as the sulphur or the carbon. H. H. Ho.

15. *Determination of Sumner Line.* **G. W. Littlehales.** (Washington Acad. Sci., Journ. 4. pp. 505–509, Nov. 4, 1914.)—A simplified method of determining the Sumner line is suggested and illustrated, being applicable

whenever the hour angle of the observed celestial body is within two minutes of being a multiple of ten minutes at the time of observation. This has been rendered possible by the publication of the azimuth of true bearings for all declinations up to 70°, north and south, at intervals of ten minutes of hour angle for the entire circuit of the sky, and for parallels of latitude extending to 70° from the equator. C. P. B

16. *Sun's Place in the Star Sphere.* **O. R. Walkey.** (Roy. Astronom. Soc., M.N. 74. pp. 649–655, May, 1914.)—An attempt is made to determine the position of the sun in the galactic sphere by the method of measuring by star counts the relative star density in different parts of the sky. Evidence is found for thinking that the solar system is situated somewhat northward of the galactic plane, and nearer the Cygnus region than that in Argo. C. P. B.

17. *Fluctuations of Epochs of Sun-spot Maxima and Minima.* **J. B. Dale.** (Roy. Astronom. Soc., M.N. 74. pp. 664–669, June, 1914.)—The investigation was undertaken with a view of ascertaining whether the deviations of the epochs of sun-spot maxima and minima from a uniform arithmetical progression could be represented by a periodic formula such as that employed by Chandler for representing the epochs of maxima of variable stars. The evidence of the existence of periodic terms appears to be fairly strong, but the data seem to be affected with accidental errors of such amount that the amplitudes and phases cannot be determined with sufficient accuracy to construct a satisfactory formula. C. P. B.

18. *Radial Motion in Sun-spots.* **J. Evershed, C. E. St. John.** (Astrophys. Journ. 40. pp. 156–159, July, 1914.)—Correspondence relating to the differences found in the spectra of sun-spots, chiefly concerning the observation by Evershed that there was an appreciable discontinuity in the spectrum lines at the points where they pass from the penumbræ on to the surrounding photosphere. St. John, using a solar image 170 mm. diam., found no sharp break, and the displacement did not cease at the periphery of the penumbra, but the line gradually returned to its normal position. Evershed calls attention to the integration caused by long exposures rendering exact adjustment of the spot on the slit very difficult, but St. John says that even with visual observation at any one instant no abrupt change in the course of the spectrum lines was detected. The question is to be further examined during the next sun-spot maximum. C. P. B.

19. *Radial Motion in Sun-spots.* **W. H. Julius.** (Astrophys. Journ. 40. pp. 1–32, July, 1914.)—In discussing the results of an exhaustive series of spectrograms showing displacements of lines in sun-spot spectra [Abstract No. 412 (1914)] St. John concluded that they were most satisfactorily explained as being due to motion in the line of sight. The present author wishes to prove that his theory of anomalous dispersion is better suited to the explanation of the phenomena, and devotes a long discussion to the possibility that differences of density in the regions of the sun-spot vapours are the main factors. One of the main points is that the displacements at the limb vary with the intensities of the lines, being greatest for lines of intensity 5, 6, 7, and gradually decreasing for greater as well as for smaller intensities. The relation existing between displacements and wavelength is considered as more in accordance with the dispersion theory. C. P. B.

20. *Pyrheliometric Observations on Mount Whitney.* **A. K. Ångström** and **E. H. Kennard.** (Astrophys. Journ. 39. pp. 350–360, May, 1914.)—Observations were made with an Ångström pyrheliometer on the summit of Mount Whitney (4410 m.), and included measurements of the total radiation and of the radiation in a special part of the spectrum. The observations are discussed in detail, and the solar constant is given as deduced from different computations: (*a*) from selected part of spectrum, 1·929; (*b*) by Ångström-Kimball method, 2·019; (*c*) by Fowle's method, 1·960 cals. per cm.^{2} per min.
C. P. B.

21. *Determination of Sun's Temperature.* **G. A. Shook.** (Astrophys. Journ. 39. pp. 277–298, May, 1914.)—Utilising the 6-in. equatorial telescope of the University of Illinois, a series of determinations of the solar temperature were made by the method based on Planck's formula for the visible spectrum, the brightness of the sun's disc being compared photometrically with the brightness of a miniature glow-lamp for three different colours. Details are first given of the measurements taken for the absorption coefficients of the coloured glasses used. The solar temperatures are determined at various parts of the disc, each position for three different colours, red, green, and blue. The resulting temperature adopted depends to some extent on the method of reduction employed, varying from 5830° to 7580° abs. An attempt was also made to measure the absorption of the green light in the atmosphere of the earth.
C. P. B.

22. *Analysis of the Motion of the Moon.* **E. W. Brown.** (Opening Address to British Assoc., Australian Meeting, 1914. Nature, 94. pp. 184–190, Oct. 15, 1914. Engineering, 98. p. 653, Nov. 27, 1914.)—The address gives a popular account of the long analysis made for some years past in the endeavour to provide more accurate tables of the motion of the moon. The determinations of the constants of eccentricity, inclination, and of the positions of perigee and the node are practically certain; the outstanding parts still requiring explanation are the deviations in the mean longitude. A long discussion is given of the different values found for the earth's ellipticity, and a plea entered for the systematic adoption of photographic records of the moon's position.
C. P. B.

23. *Physical Theory of Jupiter.* **T. E. R. Phillips.** (Observatory, No. 479. pp. 367–371, Oct., 1914.)—The note is a review of an interesting publication by H. E. Lau, of Copenhagen, on the *Rotation of the Planet Jupiter* [Astronom. Nachr. 195. No. 4673]. Lau's chief conclusions are: (*a*) Polar flattening 1 : 17. (*b*) The true surface of the planet consists of a bright yellow strongly reflective cloud envelope. Above this cloud envelope lies a very thin stratum, whose height is about one-tenth of a second of arc. (*c*) In the upper surface strata, the daily rotation angle diminishes from the equator to the poles from 880·2° to 870·3°. The greatest diminution occurs near latitudes ± 7°, this region making a sort of boundary between the equatorial current and the polar areas. (*d*) The regions of the equatorial zones or belts are the real spot zones of the planet. The belts consist of dark spots, the dark material of which streams partly eastward and partly poleward. (*e*) The bright spots are apparently clouds overlying the hottest places. Their brightness varies with the sun-spot activity, producing a periodic change of brightness of the planet. (*f*) The Red Spot is an abnormally heated region in the deeper strata of the gaseous envelope. The Bay is caused by the streaming outwards of the higher strata over the Red Spot, pushing the material of the belt back.

The reviewer criticises some of the conclusions, particularly suggesting that the observations scarcely warrant the relation of the light spots to sunspot activity, and a more extended series of observations is required to settle the point. C. P. B.

24. *Dimensions of System of Saturn.* **P. H. Hepburn.** (Roy. Astronom, Soc., M.N. 74. pp. 721–731, June, 1914.)—The author has made a series of measurements on a photograph of the planet Saturn taken by Barnard with the 60-in. reflector at Mount Wilson, on 1911 Nov. 19, using an equivalent focal length of 100 ft. Several striking discrepancies are shown by these photographic dimensions from the values derived by several observers visually, and a plotted chart of the ring system brings this out very clearly. In the discussion as to the cause of the difference, it is considered whether it may be due to systematic errors in the micrometric movements of convex compared with concave outlines, or differences in the photographic or visual images; or physical changes in the planetary system. An interesting statement is that the author finds evidence of the transparency of the ring A, and also that its surface is not uniformly bright. An old report by Trouvelot in 1885 is quoted showing that the transparency of the ring A was suspected at that time. Full details are given of the measures of the system. C. P. B.

25. *Variable Satellites of Jupiter and Saturn.* **P. Guthnick.** (Astronom. Nachr. No. 4741. Nature, 93. p. 489, July 9, 1914. Abstract.)—From observations of the satellites of Jupiter and Saturn since 1904, it is found that the inner satellites of both systems exhibit a principal maximum about the time of eastern elongation, while the outer satellites show a pronounced maximum near western elongation. C. P. B.

26. *Visual Observations of Halley's Comet in* 1910. **E. E. Barnard.** (Astrophys. Journ. 39. pp. 378–404, June, 1914.)—Complete details are given of a very systematically arranged series of visual observations of the comet in 1910, partly by the unaided eye, and with the 40-in. Yerkes refractor. Many of the points are illustrated by photographic reproductions showing the changes in the form and position of the tail. C. P. B.

27. *Spectrum of Comet* 1914*b* (*Zlatinsky*). **V. M. Slipher.** (Lowell Observatory Bull. No. 63. Nature, 93. pp. 653–654, Aug. 20, 1914. Abstract.)—Three photographs of the spectrum of this comet were obtained at the Lowell Observatory on May 25, 26, 27, using a single-prism spectrograph attached to the 24-in. refractor. To differentiate between the spectrum of head and tail a long slit was used, and the bands produced are tabulated in two classes. Long lines include the carbon and cyanogen bands. The general spectrum was found to be similar to that of Comet 1912*a* (Gale) and Comet 1911*c* (Brooks). C. P. B.

28. *Elements of Eclipsing Variables.* **H. N. Russell** and **H. Shapley.** (Astrophys. Journ. 39. pp. 405–427, June, 1914.)—The method of least squares is applied to the derivation of the definitive elements from photometric data determined by Dugan for the two eclipsing visible stars Z Draconis and RT Persei. C. P. B.

29. *Photographic Magnitudes of Southern Stars.* **J. Halm.** (Roy. Astronom. Soc., M.N. 74. pp. 600–622, May, 1914.)—The principal object of the investigation is to establish a system of photographic magnitudes which may be used as a basis for the standardisation of the magnitudes of the Cape Astrographic Zones. The derivation of such a system is dealt with in the investigation of the photographic magnitudes of the C.P.D. stars within 1° of the South Pole. The derived magnitudes of these polar stars are then utilised for determining the corrections to the C.P.D. system in 24 areas distributed at nearly equal intervals along the parallel —45° Declination. The latter part of the paper deals with a provisional determination of the differences (photographic—visual magnitude) and the star's colour depending on the spectral type. C. P. B.

30. *Photometric Tests of Spectroscopic Binaries.* **J. Stebbins.** (Astrophys. Journ. 39. pp. 459–484, June, 1914.)—The extreme sensitiveness of the selenium photometer rendered it possible to examine certain of the known spectroscopic binaries for evidences of light-variation due to mutual eclipses of the two components. The epochs when the eclipsing, if present, should be at maximum were computed from the orbital elements spectroscopically determined, and of eleven stars examined, four—β Aurigæ, δ Orionis, α Virginis, α Coronæ—were found to show variations in brightness suggestive of eclipsing conditions. C. P. B.

31. *Spectrographic Orbit of SZ Tauri.* **E. S. Haynes.** (Lick Observatory, Bull. 8. No. 259.)—Variations of the light of this star were found by Schwarzschild to have a range from 7·17 to 7·78 mag., with a period of 3·1484 days, and the star is classified by Hartwig as belonging to the ζ Geminorum type. Shapley having recently shown analytically that the variability of SZ Tauri, RV Camelopardalis, and S Antliæ may be explained on the assumption that their light-changes are due to the axial rotation of single ellipsoidal bodies, Haynes obtained a series of spectrograms at the Lick Observatory to put the theory to test. The radial velocities at different epochs were determined and plotted according to phase, and from the velocity curve thus secured preliminary elements were determined by graphical methods. The max. velocity of approach was found to be —18·49, and of recession +8·39 km. per sec. Attention has been called by Hertsprung to the similarity of the proper motion of SZ Tauri to that of the *Taurus* stream, but the foregoing velocities indicate that the star does not belong to the group, whose common velocity is of the order of +40 km. per sec. C. P. B.

32. *Photographic Determination oj Star Colours in Cluster M13.* **E. E. Barnard.** (Astrophys. Journ. 40. pp. 173–181, Sept., 1914.)—Comparisons have been made of the star images in Cluster M13 (Hercules) as shown on two plates taken under different conditions. One, made with the 13-in. astrographic refractor at Potsdam, shows the stars under ordinary photographic conditions, with the blue rays predominant; the other, made with the 40-in. Yerkes refractor, with a yellow colour-filter and isochromatic plate, giving an image closely resembling that seen by the eye with the same instrument. Reproductions of the two photographs are given, with an index, map, and list of the stars affected. The conclusion is that of a total of 144 stars examined, 100 are yellow and 44 blue. C. P. B.

33. *Distribution in Space of Stars round the North Pole.* **F. W. Dyson.** (Nature, 93. pp. 599–602, Aug. 6, 1914. Paper read before the Royal Inst.,

April 24, 1914.)—For convenience in dealing with the large numbers involved in the determination of star distances, a unit called the *parsec* has been devised, corresponding to that distance at which a star has a parallax of 1″. From a study of the proper motions of stars down to 11·0 mag. it is found that on the whole the yellow stars, most like the sun in physical condition, are the nearest. They lie within fairly narrow limits of distance, 80 % being between 100 and 500 parsecs, 10 % nearer the 100 parsecs, and 10 % farther away than 500 parsecs. Passing from the yellow to the blue or orange stars, the average distance increases, while the red stars are at very great distances, of the order of 1000 parsecs. The conclusions favour the view of a finite stellar universe with the solar system near the centre. C. P. B.

34. *Darkening at Limb of Star Discs.* **H. Shapley.** (Astrophys. Journ. 40. pp. 219–225, Sept., 1914. Contribution from Mt. Wilson Solar Observatory, No. 86.)—Examples have previously been given [Abstract No 1614 (1913)] of the solution for the orbital elements of eclipsing binaries on the hypothesis that the stellar discs are darkened to zero at the limb according to an assumed cosine law. This degree of darkening is in excess of that found in the case of the sun, and the theory is now applied to the calculation of the elements of binaries on the assumption of intermediate degrees of darkening. The system of Algol, β Persei, is taken as illustration.

C. P. B.

35. *Change of Spectrum and Colour Index with Distance.* **J. C. Kapteyn.** (Astrophys. Journ. 40. pp. 187–204, Sept., 1914. Contribution from the Mt. Wilson Solar Observatory, No. 83.)—Evidence available is discussed regarding its bearing on the two observed phenomena, (1) That on the average the apparently fainter stars are redder than the brighter ones; (2) Apparent magnitude and spectral lines being the same, the stars are redder on the average the farther away they are. The investigation is concentrated on three lines: (*a*) on the relative frequency of the several spectral classes among the stars of the fainter magnitudes; (*b*) on the influence of absolute magnitude on the spectrum; (*c*) on the influence of distance on the spectrum. C. P. B.

36. *Spectroscopic Binaries and Velocity of Light.* **R. S. Capon.** (Roy. Astronom. Soc., M.N. 74. pp. 658–659, June, 1914.)—A correction is given to the deduction of Doppler-effect calculated in a former paper [Abstract No. 1815 (1914)], which takes account of the variable frequency dependent on the distance of the observer from the light source. The correction only affects the discussion of the Ritz hypothesis, which is thereby definitely disproved.

C. P. B.

37. *Colours of Faint Stars.* **F. H. Seares.** (Astrophys. Journ. 39. pp. 361–369, May, 1914. Contribution from Mt. Wilson Solar Observatory, No. 81.)—During recent years there has been an accumulation of evidence that the faint stars are, as a class, appreciably redder than the brighter objects. Support has been given to this view by photographs taken at Mount Wilson with red and blue filters. A good foundation for the study of this question is furnished by the determinations of the photographic scale of North Polar sequence, one of which has been made at Harvard, the other at Mount Wilson. With the exception of a divergence of about 0·4 mag. between the sixth and tenth magnitudes, their agreement is very satisfactory. It remains to complete the scale for the visual values, and this has been attempted at Mount Wilson by the photographic method, using isochromatic plates and a yellow filter. The observations for the colour indices are collected in a diagram showing their

distribution for the region of the Pole. As regards spectrum, it is found that in cases where the absolute magnitudes are known there is a rapid increase in spectral type with increasing absolute magnitude. Whether this feature is due to an actual change in spectral type for the various groups of stars, or whether it is related to the intensity distribution of the continuous spectrum, cannot be yet decided. The presence of an absorbing medium in interstellar space would account for the fact, but this has not yet been definitely established. C. P. B.

38. *Photographic Stellar Photometry.* **F. H. Seares.** (Astrophys. Journ. 39. pp. 307–340, May, 1914.)—An account is given of the methods used in the investigation of photographic photometry with the 60-in. reflector at the Mount Wilson Solar Observatory in California. One of the most important applications which has been developed is the determination of faint standards of magnitude, and is carried out by successive exposures on the same plate, first with full aperture, second with the intensity reduced by a known amount. The assumption made is that equal photographic effects produced during equal exposure times must be caused by equal light-intensities. Whether this is modified by the alteration of the diffraction disc by the change in aperture, and the possible interference of atmospheric disturbances, are discussed in detail. The methods employed for the determination of the absorption constants of the screens, and for the measurement of the plates, are fully described, with examples of the calculations. C. P. B.

39. *Radial Velocities of Stars of Known Parallax.* **W. S. Adams** and **A. Kohlschütter.** (Astrophys. Journ. 39. pp. 341–349, May, 1914. Contribution from Mt. Wilson Solar Observatory, No. 79.)—Radial velocities are given for 100 stars fainter than visual magnitude 5·5 for which observations of parallax are available. These stars are in general those nearest the solar system, and a knowledge of their spectral type is also of importance, since their absolute magnitudes may be calculated with the aid of the parallax values. The work has been done with the Cassegrain spectrograph attached to the 60-in. reflector [Abstract No. 1624 (1913)]. Two cameras were employed, giving 16 Å. and 36 Å. to the mm. respectively. In the analysis of the results several interesting points are emphasised. Two stars show enormous radial velocities, —325 and —242 km. per sec. There is a great preponderance of large negative over large positive velocities. Examination of the spectral types shows that nearly all types are represented. Two stars, *Groom.* 34 and *Lal.* 21185, show very large proper motions and parallaxes, and are among the faintest stars known. Their spectra are both of type Ma. C. P. B.

40. *Parallaxes of Brighter Galactic Helium Stars.* **J. C. Kapteyn.** (Astrophys. Journ. 40. pp. 43–126, July, and p. 204, Sept., 1914.)—The paper gives the results of an exhaustive study of the individual parallaxes of almost all the known helium stars brighter than the sixth magnitude for that part of the sky lying between galactic latitudes + 30° and galactic longitudes 216°–360°, reserving for a future paper the discussion of the data for the rest of the sky. Tables are given showing the constants and deduced parallaxes for 319 stars, and the resulting space distribution is illustrated by a map plotted with parallax and galactic longitude as co-ordinates. C. P. B.

41. *Hypothetical Parallaxes of Helium Stars.* **H. C. Plummer.** (Observatory, No. 478. pp. 344–347, Sept., 1914.)—The problem of directly measuring the parallaxes of the bright helium stars seems to be impracticable with present apparatus, owing to the extreme distances of these bodies, and some

time ago the author suggested hypothetical parallaxes based on other considerations than direct measurement, such as proper motion, radial velocity, etc. Kapteyn has recently [see preceding Abstract] given a long discussion on the determination of the individual parallaxes of the brighter galactic helium stars in the southern sky, proceeding by the method of stream-motions which he employed in his work on the streams in Taurus and Ursa Major, the parallax being computed from a formula involving the stream velocity, angular distance of star from the vertex, and the component of the proper motion away from the vertex. Plummer now compares his results with Kapteyn's for the 97 stars common to their two lists, showing the very close agreement in most cases. C. P. B.

42. *Spectrum of Wolf-Rayet Star A.G.C. 22,748.* **G. F. Paddock.** (Lick Observatory, Bull. No. 257, 1914.)—Three plates of the spectrum of this interesting bright-line star were secured at Santiago, Chile, at intervals between 1908 and 1912. The reductions furnish details of the radial velocity of the star, about —60 km. per sec. and also somewhat closer details of the spectrum than have previously been available. Nine lines are tabulated, one due to helium, one to ordinary hydrogen, one to new hydrogen; the remaining are of unknown origin. C. P. B.

43. *Classifications of Nebulæ and Star Clusters.* **G. Bigourdan.** (Comptes Rendus, 158. pp. 1949–1957, June 29, 1914.)—A summary is given of the many systems of classification of nebulæ and star clusters which have been devised by the respective observers. From the discussion a table is drawn up embodying most of the terms generally acknowledged, and suggesting the employment of a numerical synonym for each object, this being instantly identifiable by reference to the table. C. P. B.

44. *Star with Bright Hydrogen Spectrum.* **J. H. Moore.** (Lick Observatory, Bull. No. 257, 1914.)—The star A.G.C. 17270, class B_8, shows bright lines in its spectrum as photographed with a two-prism spectrograph at Santiago, Chile. On all the plates obtained the hydrogen line H_β appears as a double bright line superimposed upon a very broad absorption line. H_γ also shows this same structure, but the bright components are finer than those of H_β. The star is not included in other lists of stars showing bright lines. C. P. B.

45. *Stars with Variable Radial Velocity.* **J. H. Moore.** (Lick Observatory, Bull. No. 257, 1914.)—From observations made with a two-prism spectrograph at Santiago, Chile, it has been found that the spectra of 17 stars show evidence of variable radial velocity. Details are tabulated, showing position, magnitude, spectral class, and velocity at each epoch of observation. C. P. B.

46. *Stars with Large Radial Velocities.* **J. H. Moore.** (Lick Observatory, Bull. No. 257, 1914.)—The spectra of two stars photographed at Santiago, Chile, show evidence of specially large motion in the line of sight. One, A.G.C. 7195, is of class G; the other, ω Pavonis, of class K; both have velocity of + 184 km. per sec. C. P. B.

47. *Nebular Line λ3729.* **J. W. Nicholson.** (Roy. Astronom. Soc., M.N. 74. pp. 623–628, May, 1914.)—Photographs of nebulæ with prismatic cameras have indicated that more than one unknown element enters into their composition. The recent investigations of Bourget, Fabry, and Buisson by their interferometer method afford further proof of the reality of this feature, and the fact is used by Nicholson to illustrate a further step in his theory for investigation of the constitution of elements. For the element giving rise to the spectrum line λ3729 the interferometer method gives the atomic weight 2·72, while the nearest theoretical value is 2·95, called Archonium. Another line, λ4069, is associated with λ3729, but it is much weaker. Preliminary measurements on the principal nebulium line λ5007 are in progress by Bourget, Fabry, and Buisson, and appear to favour the value 1·31 for the atomic weight of nebulium. C. P. B.

48. *Rotation of Nebulæ.* **V. M. Slipher.** (Lowell Observatory, Bull. No. 62. Nature, 93. p. 594, Aug. 6, 1914. Abstract.)—Details are given of the evidence for rotation in the Virgo nebula. About a year ago a spectrogram of the nebula was obtained showing inclination of the spectrum lines, and recent photographs have confirmed the first conclusions. The nebula is one of the spindle-shaped type, the slit being placed over the long axis. The result is an interesting confirmation of the view that these elongated nebulæ are simply spiral nebulæ seen edgewise. C. P. B.

49. *Interference Spectral Study of Orion Nebula.* **H. Buisson, C. Fabry,** and **H. Bourget.** (Journ. de Physique, 4. Ser. 5. pp. 357–378, May, 1914. Astrophys. Journ. 40. pp. 241–258, Oct., 1914.)—By employing a projecting mirror of large aperture (80 cm.) it has been found possible to study the constitution of the Orion nebula by the well-known interferometer method, using an étalon with adjustable distance between the plates from 0·1 to 3 mm. Special attention had to be paid to the silvered surfaces, since it was necessary that as little light as possible should be stopped. Two groups of photographs were obtained, one on the H_γ image, the other on the ultra-viotet radiation at λ3728. The radial velocity for the region of the trapezium was found to be +15·8 km. per sec. (values found by other observers by ordinary spectroscopic method vary from +16·2 to +18·5 km. per sec.). The wave-lengths of the two components of the ultra-violet line are λ3726·100 and λ3728·838, the former being the stronger line. The measurements of the limit of interference enabled an estimate of the atomic weight of the element producing the lines to be made, and also the temperature of the source. The probable atomic weight is given as nearly 3, and the temperature as 15,000° C. P. B.

50. *Zodiacal Light.* **K. Birkeland.** (Comptes Rendus, 159. pp. 229–231, July 20, 1914.)—So many of the theories concerning the cause of the zodiacal light have failed to provide satisfactory explanations of the phenomena that the author is encouraged to propose a new theory which he has developed from the results of a long series of observations. Radiant matter is supposed to be emitted from the sun, the particles being particularly grouped round the region of the sun's magnetic equator. These particles may then act as a diffusing medium for solar light passing through the ring. C. P. B.

51. *Theoretical Form of Zodiacal Light.* **K. Birkeland** and **Skolem.** (Comptes Rendus, 159. pp. 464–467, Aug. 31, and pp. 495–497, Sept. 14, 1914.)—Assuming that the zodiacal light is due to light diffused by a ring-like structure of electrons or radiant matter driven from the sun, a series of lines of equal intensity are computed on three suppositions differing with regard to the distribution of the particles. The resulting form may be compared with the observed features of different epochs and by different observers. One of the series is very similar to that seen during the special expeditions to Khartoum in 1911 and 1913–14. C. P. B.

LIGHT.

52. *Improvements in Stellar Spectrographs.* **J. S. Plaskett.** (Astrophys. Journ. 40. pp. 127–136, July, 1914.)—Realising that the dense silicate flint glass O 102 Jena, which has been extensively used for stellar spectrographs is too highly coloured and absorbent in the ultra-violet, experiments were made with other glasses in the endeavour to find a better for use in a single-prism instrument. Baryta Light Flint O 722 was selected, and a prism of 61° 57′ angle obtained. From a series of comparative exposures it was found possible to reduce the exposure times by 22 % at H_γ, 48 % at H_δ, and 70 % at K. Considerable improvement was effected by cementing the contact curves of the objectives of camera and collimator, thus diminishing the losses by reflection. C. P. B.

53. *The Coudé Equatorial.* **M. Hamy.** (Comptes Rendus, 159. pp. 505–511, Sept. 21, 1914.)—Notes are given of the design of a type of Coudé somewhat different from that constructed by Loewy, and used for the photographic chart of the moon. The older instrument is somewhat restricted in its reach to certain declinations, and the new design aims at avoiding these without involving too great incidence angles on the movable mirror. Figures are given for an instrument of 18 m. focal length. C. P. B.

54. *Vertical Rowland Mounting for Concave Grating.* **A. S. King.** (Astrophys. Journ. 40. pp. 205–212, Sept., 1914. Contribution from Mt. Wilson Solar Observatory, No. 84.)—Details are given of new structural features embodied in the installation of a 15-ft. concave grating on the Rowland plan, but with the plane of dispersion vertical instead of the more usual horizontal disposition. The arrangement permits placing the grating in a pit beneath the laboratory floor, thereby obtaining the constancy of temperature which has proved highly advantageous with plane grating spectrographs. The apparatus is so constructed that it may be operated in a fully lighted room, and occupies a minimum of floor space. An ingenious arrangement is provided to allow for the variable counterpoise necessary on account of the changing angle of the beam to the vertical. C. P. B.

55. *Large Telescopes.* **H. P. Hollis.** (Observatory, No. 475. pp. 245–252, June, 1914.)—Detailed tables are given showing particulars as to aperture, focal length, situation, date of installation, optician, and other interesting features concerning the large telescopes of the world. The instruments vary from 49·2 in. to 20 in. for the refractors, and from 100 to 20 in. for the reflectors. C. P. B.

56. *Brightness and Contrast in Optical Images.* **P. G. Nutting.** (Astrophys. Journ. 40. pp. 33–42, July, 1914.)—The author works out the theory of brightness of an image completely for portions of object and image near the axis and normal to it, and for an object at any distance, with any focal length of mirror or lens. The treatment is not extended to oblique pencils. Experimental methods, it is stated, have been developed to a point where determinations are scarcely more uncertain than photometric settings. The experimental method finally adopted was, in brief, to form an image of an extended plane source, by means of the lens under test, upon a matt white-

reflecting surface of magnesium carbonate. The illumination of this image is compared with that of the same spot with the lens removed. Light from the same source is used to illuminate both lens and comparison surface, and careful determination of stray light is made. Calling the illumination at the source I_0, that at the receiving screen without the lens I_1, and that with the lens I_2, then the ratio I_1/I_0 is computed from dimensions and distances, while I_1/I_2 is observed with the photometer, hence I_2/I_0, the relative illumination of object and image, is obtained. The source used is a 1500-c.p. tungsten lamp in a box with a front of opal glass. The receiving block is 5 m. from this face. The photometer used is a modified Beckstein illuminometer. It is not possible here to reproduce the mathematical reasoning by which the following general expression for relative illumination of object and image is obtained :—$I/\pi I_0 = 1/(1 - m^2)^2 . \log(\cos^2 U/\cos^2 V) - \sin^2 U/(1 - m)^2$, where $m = v/u$, $\cos^2 U = u^2/(u^2 + R^2)$, $\cos^2 V = v^2/(v^2 + R^2)$; u, v are distances of object and image, and 2R is the aperture. By making appropriate substitutions this equation is reduced to the form better adapted for computation :—$I/\pi I_0 = M^2 \log[(1 + S)/(1 + T)] - M I/(1 + T)$. If the object is infinitely distant, the right-hand side becomes $-\log \cos^2 V = \sin^2 V$ approximately. In the special case of object and image at equal distances, in which the above equation becomes indeterminate, we have $I/\pi I_0 = (2w^2 + 1)/2(w^2 + 1)^2$, where $w = R/u$. The above expressions contain a slight error due to neglecting curvature of an elemental lens surface, but the author shows how to find the correction. The results of comparison of theory and experiment for several lenses are quoted.

Contrast.—Large details of an image are of course of the same relative brightness to one another as the corresponding details of the object. But details beyond the resolving power of the instrument may gain or lose enormously in contrast relative to their background, accordingly as they are points or lines, and are brighter or darker than the background. Let F denote the focal length, D the diam. of the objective, A the aperture ratio, and δ the diam. of the diffraction disc. Then $\delta = F/D$ approximately. For a portion of a telescopic photographic image well above the limit of resolution, the ratio of brightnesses of image and object is D^2/F^2. Details below the limit of resolution are spread out over a width δ, and for these the ratio is $D^2/\delta^2 = A^2D^2/\lambda^2$ for a point object, and $D^2/\delta = AD^2/\lambda$ for a line object. For a visual image the ratio is constant. For *light* details on a darker background, max. contrast in a photographic image is obtained by increasing the brightness of detail over background. If the object is a point there is clear gain in increasing D ; if a line, in increasing either D or F or both. In a *visual* image there is gain in increasing either A or D. With *dark* details on a lighter background the conditions for max. contrast are quite different. If the dark detail is a point, photographic contrast is proportional to $1/D^2$, and D should be small. If the detail is a dark line, then both D and F should be small. Contrast in dark details on a lighter ground in *visual* images is proportional to $1/A^2D^2$ for points, and $1/AD^2$ for lines, hence, here also, D and F should be small. "In observing or photographing fine dark details on Mars, for example, in so far as contrast is concerned, there is practically no advantage, but a considerable disadvantage, aside from atmospheric disturbances, in using a large telescope. W. H. Pickering (Fourth Monthly Report on Mars) prefers in practice about an 8-in objective as the best compromise."

The above principles are of interest in explaining the widely varying images of the same object obtained with different instruments. A. E.

57. *Photometry of Diffuse Reflection.* **L. Grabowski.** (Astrophys. Journ. 39. pp. 299–306, May, 1914.)—Most of the theories of diffuse reflection are concerned with the somewhat restricted assumption that the equation of condition does not contain the azimuth of emanation, thereby implying that the emanation is equally distributed with respect to the normal. Experimental investigations, however, do not bear out the validity of this assumption, many substances not diffusing in a circular manner, and of those that do there are various deviations found in special cases. Much of the present paper is occupied in proving that Bouguer's theory, in which he supposes that each element of the diffusing surface consists of countless infinitely small mirrors which are pointed towards all possible directions, is untenable. C. P. B.

58. *Index of Refraction and Density of Gases.* **A. Occhialini.** (N. Cimento, 8. Ser. 6. pp. 123–155, Aug., 1914.)—Magri (1904) has shown that, at pressures up to 200 atmos., the refractive indices of air give values for the Lorenz and Lorentz formula which are appreciably more constant than those calculated by means of Drude's or Gladstone and Dale's expression. The author has extended Magri's observations by measuring the indices of refraction and the corresponding densities of nitrogen and oxygen at various pressures up to 200 atmos. and of CO_2 up to the saturation-point at 21°. The max. percentage variations of the value of the Lorenz and Lorentz formula are 0·05, 0·3, and 0·2 for nitrogen, oxygen, and CO_2 respectively, such variations lying within the limits of experimental error. For Drude's and Gladstone and Dale's formulæ the corresponding percentage variations are respectively 2·8 and 8·5 for nitrogen, 2·7 and 0·8 for oxygen, and 1·4 and 0·5 for CO_2. The value of $(n^2-1)/(n^2+2)\,E$ is 1997×10^{-7}, 1815×10^{-7}, and 3003×10^{-7} for the three gases respectively. These results show that the value calculated by the Lorenz and Lorentz formula, for the index of refraction of a gas at any particular density is more accurate than that obtainable by direct measurement. T. H. P.

59. *Formulæ for Cylindrical Lenses combined at Oblique Angles.* **C. Sheard.** (Phys. Rev. 4. Ser. 2. pp. 274–277, Sept., 1914.)—The solution of the problem of transposing double cylinders at oblique angles into their equivalents with axes at right angles (the so-called cross-cylinder combination) has previously been worked out by C. F. Prentice, but his method is somewhat involved and lengthy, and lacks simplicity in its application. An outline is here given of a new method, applying the principle of curvatures. The results are simply obtained, and are easy to manipulate. Tables have been prepared to facilitate the calculations. A. W.

60. *Zone-tests of Telescope Objective.* **J. A. Miller** and **R. W. Marriott.** (Frank. Inst., Journ. 178. pp. 465–481, Oct., 1914.)—Details are given of a series of zonal tests by the Hartmann method of the 24-in. objective of the Sproul Observatory, U.S.A. Tables are given showing the results of the measurements, from which it is calculated that the objective is an excellent one. C. P. B.

61. *Visibility of Faintly Illuminated Objects.* **P. G. Nutting.** (Nature, 93. p. 480, July 9, 1914.)—The question frequently arises, particularly in astronomical photography, whether it is possible to photograph objects too faintly illuminated to be seen. To test the conditions a series of observations have been made with measured illuminations giving comparative sensibilities of the human retina and an extra-rapid photographic plate.

The source of light was a 10-c.p. tungsten lamp in a metal box, over the front of which were placed several layers of dense opal glass, the normal light flux being 8·6 candle-metres. This was further reduced by neutral filters, and placed at one end of a tube 20 ft. long. At the other end was a 6-in. $f/5{\cdot}8$ telescope objective, which formed an image on the retina of the eye or on the plate to be tested. The retina was found to be far more sensitive than the photographic plate tested (Seed 30). C. P. B.

62. *Optical Character of the Faint Interference Figure observed in High-power Objectives between Crossed Nicols.* **F. E. Wright.** (Washington Acad. Sci., Journ. 4. pp. 301–309, June 19, 1914.)—To the petrologist the appearance in question is a matter of common observation. It was at first considered to be the result of strain in the objective, but Rinne in 1900 gave the correct explanation, and ascribed it to rotation of the vibration plane of the transmitted plane-polarised waves at the steeply inclined lens surfaces. [See also Wright, Abstract No. 763 (1911).] Rotation of this kind was noted by Fresnel, who deduced, in 1822, for plane-polarised waves transmitted through an isotropic plate, the equation $\cot B = \cos^2 (i - r) . \cot A$, where B is the angle of rotation, and A the azimuth of the plane of vibration of the incident light-wave. This equation shows that the rotation increases with i, also that for a given value of i the rotation B is maximum when the normal to the wave-front is in the diagonal plane between the principal planes of the crossed nicols, or $A = 45°$. If a sensitive tint plate be inserted along the NW.–SE. diagonal, between crossed nicols either below the condenser or above the objective, the quadrants of the faint interference cross, observed in the upper focal plane of the objective, appear differently coloured, the NE. and SW. quadrants being blue-green and the other two quadrants orange-yellow; or *vice versa* if the tint plate be inserted along the NE.–SW. diagonal. The arms of the interference cross assume the colour of the sensitive tint plate irrespective of its direction. The interference colours are much more distinct when the sensitive tint plate makes only a small angle (1° to 10°) with the principal nicol planes. This distribution of colours in the interference figure on inserting the sensitive tint plate is precisely that observed on a weakly birefracting, optically positive, uniaxial mineral under similar conditions, and would lead one to infer that the objective is uniaxial and optically positive in character. The author inquires into the cause of the conversion of an isotropic substance like glass into an apparently uniaxial, optically positive substance. He describes five experiments which show that the phenomenon is due to rotation of the plane of vibration at the steeply inclined surfaces of the glass. In passing from one isotropic substance to a second, the direction of vibration remains, of course, in the same plane, but the azimuth of the plane of vibration suffers rotation owing to the change of direction of the ray (wave normal) on refraction. The deduction is verified by computation from Fresnel's formula, the results being shown in graphical and tabular form. If θ be the angle between the vibration direction of the tint plate and the principal plane of the analyser, the table and curves show that for $\theta = +1°$ the intensity of the transmitted light is not the same throughout the spectrum for a given angle ϕ between the nicols; thus for $\theta = +1°$ and $\phi = 86°$, the intensity is greatest in the green, and the resultant colour is of greenish hue; while for $\theta = +1°$ and $\phi = 98$, the intensity is minimum in the green, and the resulting hue is "of the nature of a minus green" which is magenta. Similar relations hold for $\theta = +2°$. For large angles the intensity of illumination throughout the spectrum is so great that the slight

differences for different wave-lengths are not sufficient to dominate the hue of the total light transmitted. It is only when the entire spectrum is so faint as to approach the limit of vision that the colour intensity differences are marked. Theory shows also that for a given θ the intensity of illumination is minimum when $\phi = 90 + \theta$. From the foregoing it is evident that, in weakly birefracting minerals, the colour phenomena produced in the objective alone on inserting the sensitive tint plate tend to veil and render uncertain the interference colours due to the mineral plate under observation; special care should be taken in such cases to test by other methods any inference regarding the optical character of the mineral under test. It is also evident that the rotation, by the lens system, of the plane of vibration of transmitted light, has an effect on the measures of the optic axial angle of a crystal plate: but this effect is not usually large enough to be serious. A. E.

63. *Scattering of Light.* **A. W. Porter** and **E. T. Paris.** (Engineering, 98. pp. 610–611, Nov. 20, 1914. Paper read before the British Assoc., Australia, 1914.)—This investigation, dealing with the scattering of light by small and large particles of conducting and non-conducting substances, is a continuation of that by Porter and Keen on the diffraction of light by sulphur in suspension [Abstract No. 645 (1914)]. In the recent experiments the polarisation in different directions of silver and copper suspensions had been studied by means of a double-image prism and a nicol, the suspensions being prepared after the method of Pieroni. In working with silver the size of the particles could be determined by chemical analysis combined with counting the number of particles per unit volume. The determination could also be made, after Perrin, by counting the number of particles in two layers of a vertical column. The two methods had given practically the same results. The annexed table gives the results in silver suspensions for light of wave-lengths 550 μμ:—

Diameter of Particle.	Direction of Maximum Polarisation.	Relative Electric Conductivity.
80 μμ	90 Degrees	—
98	90	$2{\cdot}96 \times 10^{-4}$
108	98·36	$3{\cdot}70 \times 10^{-4}$
131	109·54	$4{\cdot}12 \times 10^{-4}$
164	118·36	—
310	130·30	—

According to J. J. Thomson the direction of max. polarisation for perfectly conducting particles should make an angle of 120° with the incident light. From this table it would appear that the angle was 90° for very small conducting particles (as it would be for dielectric particles and was so observed by Threlfall in 1894), but that as the diam. of the particle increased the angle increased to a value above the theoretical limit.

The results are discussed on the electron theory. E. H. B.

64. *Velocity of Light and Doppler's Principle.* **H. C. Plummer.** (Roy. Astronom. Soc., M.N. 74. pp. 660–663, June, 1914.)—Examining the question of the possible modification of Doppler's principle in the case of light-waves proceeding from a luminous source moving with a variable velocity, the

author concludes that when adopting the theory of Ritz there is a definite modification. The theory demands that the periodic motion of the source shall be magnified by a large factor varying as the distance of the star and inversely as the period, so that the original motions in the case of a suspected binary system must be exceedingly small. The final conclusion is that the theory of Ritz is untenable. [See also Abstract No. 86 (1915).] C. P. B.

65. *Fizeau's Experiment and the Principle of Relativity.* **E. Cunningham.** (Nature, 94. pp. 226–227, Oct. 29, 1914.)—The author discounts the evidence afforded by Fizeau's experiment against the validity of the principle of relativity by indicating errors in the determination which render it quite indecisive. This gives great importance to the announcement that Zeeman has repeated the experiment with great care and monochromatic light, and has succeeded in observing a dispersive effect. The details of his result will therefore be awaited with much interest. G. W. DE T.

66. *Humidity Effect on Photographic Plates.* **C. E. K. Mees.** (Astrophys. Journ. 40. p. 236, Sept., 1914.)—It has been noted in astronomical photography that when several exposures are impressed on the same plate, the first and last being short and equal, the images of the first are often systematically brighter than those of the last, amounting on the average to a quarter magnitude. Experiments made at the Kodak Laboratory support the view that these differences are due to humidity of the gelatine film, the sensitiveness of the emulsion gradually decreasing. C. P. B.

67. *Pressure Displacement of Spectral Lines.* **G. H. Livens.** (Astrophys. Journ. 40. pp. 226–231, Sept., 1914.)—An explanation of the pressure shift of the lines in emission spectra has been suggested on the basis of the ordinary absorption theory of Lorentz [Abstract No. 1339 (1912)]. It was then thought that that view failed to account for the displacements to the violet which are found in several cases, but a more thorough investigation shows that this was only due to the approximations utilised. The equations required are discussed, and an interesting conclusion is that displacement of a line is mainly proportional to the density of the electrons producing it, and that in the case of series spectra, the lines of the first subordinate series are displaced about twice as much as those of the principal series, while the displacements of the second subordinate series are four times as great. C. P. B.

68. *Widening of Hydrogen Lines in Spark Spectrum.* **R. Rossi.** (Astrophys. Journ. 40. pp. 232–235, Sept., 1914.)—By passing sparks through hydrogen at atmospheric pressure under various conditions of electrical circuit, it is concluded that the chief factor determining the width of the lines is current-density. C. P. B.

69. *Ultra-violet Band in Ammonia Spectrum.* **E. P. Lewis.** (Astrophys. Journ. 40. pp. 154–155, July, 1914.)—The ultra-violet band λ3295–λ3432, described by Eder as the principal band of ammonia, has been detected by the author in vacuum-tube spectra of mixtures of nitrogen and hydrogen at all pressures up to 70 cm., and becomes specially prominent when self-induction is employed. It was not found with nitrogen free from hydrogen, or hydrogen free from nitrogen. Small traces of oxygen appear to have no effect, while large quantities destroy it. Whereas the greenish-red band is found only on the first sparking, the ultra-violet band persists for long periods. C. P. B.

70. *Effect of Pressure on the Absorption of Bromine and Chlorine.* **D. L. Webster.** (Phys. Rev. 4. Ser. 2. pp. 177–194, Sept., 1914.)—This paper consists of two parts, one dealing with experimental work, and the other with a comprehensive theoretical treatment of the subject of absorption of light. The author describes in detail an ingenious photometer due to Pfund, with which and a Hilger spectrometer he examines chlorine and bromine vapour at different pressures. The various sources of errors are evaluated and lead to an accuracy of 1 % in all parts of the spectrum where the absorption is continuous. In the narrow bands, however, where the intensity changes rapidly errors up to 3 or 4 % may be experienced. Dealing with initial pressures of the order of 50 mm. and expansion ratios up to 39 no change of intensity can be observed at wave-lengths lying within the broad bromine band in the region 420–507 $\mu\mu$. More exactly, assuming the validity of Lambert's law for this broad band, deviations from Beer's law fall below the value 0·5 %. The narrow bands below 510 $\mu\mu$ differ sharply from this broad band in their behaviour under pressure. Under similar conditions these bands disobey both laws, and in some instances the values of I/I_0 decrease as much as 50 % with increase of pressure. This is notably the case for the bands at λλ5767 and 5460. This effect is attributed to the widening of the fine lines composing these bands. In the case of chlorine the experiments deal with the part of the band in the visible lying between 416 and 422 $\mu\mu$. A very small effect is obtained in comparison to the effects obtained by Janssen for the visible band of oxygen and by Ångström and v. Bahr for the infra-red bands of many gases. The author attributes such small effects to a temporary chemical change induced in this gas by exposure to light, a change which is indicated by the experiments of Trautz.

In the second part of the paper the author reviews the various electronic oscillation theories put forward to explain absorption of light in the upper spectral regions. Helmholtz's assumption of viscous resistance to the motion of a vibrating electron does not account for the production of heat by light of low frequencies. The damping by collisions assumed by Lorentz more satisfactorily accounts for this heating effect. As regards the possible sources of width in a band and the widths for which they can account in gases, there are (1) damping by radiation giving possibly a few thousandths of an Ångström, (2) damping by collision giving possibly a few tenths, (3) the Doppler-effect, ordinarily negligible, and (4) Livens' effect, giving perhaps a few tenths. Altogether a widening of one unit might be obtained, whereas the bands to be explained range from a few thousandths of an Ångström to hundreds in width. The further assumption must therefore be made that the natural frequencies of the electrons, when free from all electrostatic influences of their neighbours, are not so nearly equal as has heretofore been assumed. The consequences of this hypothesis are then traced out. On this view, for instance, the broad bands of bromine and chlorine arise from intramolecular motions practically unaffected by collisions. Finally the heating, ionising, and chemical effects of light absorption are readily explainable.

C. S. G.

71. *Spectrum of Mercury Vapour in Electric Field.* **C. D. Child.** (Phys. Rev. 4. Ser. 2. pp. 387–390, Oct., 1914.)—It has been shown that the vapour rising from a mercury arc is luminous, and that the intensity of this light can be diminished by an electric field [Abstract No. 320 (1914)]. It has now been found that the relative intensity of the different lines in the spectrum of this light can be modified by an electric field. The horizontal discharge

tube (T) has a condensing chamber (F) connected at its middle point, and at a certain point in this chamber a piece of wire gauze occupies the whole cross-section. This gauze can be given any desired potential. The condensing chamber is connected to a pump and drying chamber. After the arc has been started, luminous vapour passes from T to F, but the luminosity can be entirely destroyed by charging the gauze positively to a potential about 10 volts higher than that of the middle of the arc. The potential needed to produce this effect varies with the amount of vapour rising from the arc. When there is a large amount of vapour it is impossible to destroy the luminosity entirely, but it can always be diminished. When the gauze is given a potential somewhat higher than 10 volts above that of the middle of the arc the luminosity is increased, and the colour changes from a reddish to a greenish tint. The difference in colour is due to changes in the intensity of the various lines in the spectrum of the light. The relative intensity of the lines in the mercury spectrum may thus be changed by altering the p.d. covered by the mean free path of the electrons. The greater this p.d. the more prominent is the green line as compared with the yellow lines. This may be explained by assuming that certain lines are produced by the union of electrons with positive ions which lack one electron, while other lines are produced by the combination of electrons with positive ions lacking more than one electron. A. W.

72. *Rate of Decay of Phosphorescence at Low Temperatures.* **E. H. Kennard.** (Phys. Rev. 4. Ser. 2. pp. 278–286, Sept., 1914.)—The rate of decay of phosphorescence at liquid-air temperatures was studied in paraffin, cetyl alcohol and kerosene, employing a photoelectric cell and an electrometer. From 0·1 sec. to 10 secs. paraffin obeys the law $I = I_0/(1 + \alpha t)^2$; after 10 secs. the decay is more rapid, whereas in crystalline substances at ordinary temperatures the later decay is less rapid. Cetyl alcohol and kerosene appeared to obey this law as far as their phosphorescence could be followed (20 secs.). Taking into account the free electrons, assumed constant in number, the formula becomes $I = I_0 e^{-\beta t}/[1 + (\alpha/\beta)(1 - e^{-\beta t})]^2$, which represents the decay for paraffin within the fairly large errors of observation. If n_0 is the initial number of phosphorescent nuclei or of corresponding ejected electrons (or other ions) present, m the number of free electrons, then $\alpha = kn_0$, $\beta = k'm$, and $I_0 = A(\alpha + \beta)n_0$. [See also Abstract No. 1896 (1906).] A. W.

73. *Photographic Action of Euphorbia Juice.* **H. G. Chapman** and **J. M. Petrie.** (Engineering, 98. p. 611, Nov. 20, 1914. Paper read before the British Assoc., Australia, 1914.)—In studying the properties of indigenous plants it was discovered that when letters are written with the milky juice of *Euphorbia peplus* on glass and the latter is fixed close to a sensitive film, sharp impressions of the letters are produced—faint impressions in one day, deeper impressions in three days, and darker prints still, and yet quite sharp, after exposure of one month. When the separation of the plates exceeds 12 mm., no impression is observed. The interposition of black paper, paraffin paper, thin Al or gold-foil, thin glass, makes little or no difference, nor does a strong air-current between the plates. The action does not appear to be radioactive, for there is no scintillation of the juice when examined with a sulphide screen, nor any discharge of an electroscope. On the other hand, the juice can be heated to 200° C., charred and even incinerated without losing its activity completely. The activity is observed with all plants of *Euphorbia peplus* from distant localities, but not with any other kind of Euphorbia.

A. E. G.

74. *Coefficient of Diffusion of X-rays by Light Substances.* **H. Guilleminot.** (Comptes Rendus, 159. pp. 56–59, July 6, 1914.)—A monochromatic beam of X-rays, when traversing a light substance, is diffused without change of quality, and the intensity, I_s, of the secondary radiation in a direction near to that of the primary beam, on the emergent side of the radiator, is given by $I_s = zI_0(1 - k^{2l})/2$, in which I_0 represents the intensity of the incident beam, z the coefficient of diffusion of the beam, k the coefficient of absorption, and l the thickness of the layer traversed. For a composite beam the formula would be $I_s = zI_0(1 - \phi_{2l})/2$, where ϕ_{2l} is the fraction transmitted through a layer of thickness l. This reduces to $I_s = \frac{1}{2}zI_0$ when l is large. It is assumed in the deduction of the last formula that z is the same for all qualities of rays. Still maintaining this assumption and considering a composite beam made up of different monochromatic constituents each of intensity I_0, the total amount of secondary radiation on the emergent side of the radiator is given by the formula $\Sigma R_s = zI_0 l \Sigma[k^l(-\log k)]$, where k is the coefficient of absorption of any constituent of the beam in the body considered. The above theoretical results are confirmed by experiment to the accuracy attainable with the apparatus employed, for paraffin and aluminium. E. A. O.

75. *Absorption Coefficients of X-rays.* **W. H. Bragg** and **S. E. Pierce.** (Phil. Mag. 28. pp. 626–630, Oct., 1914.)—The paper contains some results obtained by the use of strictly homogeneous beams of X-rays. The wave-lengths examined are those emitted by antikathodes of Ag, Pd and Rh; each of these substances yields a spectrum constituted mainly of two well-defined and intense lines. Each wave-length is isolated in turn by reflection from a crystal of rock-salt, and the absorption coefficients are measured in the usual way. The results are given in the form of atomic absorption coefficients; each expresses the proportion of energy of an X-ray pencil which is absorbed in crossing a surface on which lies one atom to every square cm. Expressed in this way the coefficient should be more strictly comparable with other atomic characteristics. The ordinary mass-absorption coefficients (λ/ρ) can be obtained by dividing any figure in the table by the assumed mass of the corresponding atom, which is given at the foot of the column to which the figure belongs—

ATOMIC ABSORPTION COEFFICIENTS × 10^{22}.

Antikathode.	Ray.	Wave-length.	Absorber.									
			Al	Fe	Ni	Cu	Zn	Pd	Ag	Sn	Pt	Au
Silver	harder	$0{\cdot}491 \times 10^{-8}$	0·86	13·0	17·2	21·8	23·4	101·5	18·2	23·8	150	155
Palladium ...	,,	0·508 ,,	1·00	16·2	20·8	23·4	26·8	20·0	22·0	29·7	167	188
Rhodium ...	,,	0·537 ,,	1·22	17·7	22·6	26·4	30·1	22·4	24·8	32·6	176	187
Silver	softer	0·554 ,,	1·20	18·7	24·1	27·8	32·4	23·8	25·3	35·4	205	213
Palladium ...	,,	0·576 ,,	1·41	21·4	27·9	32·2	36·4	28·3	30·0	39·0	238	244
Rhodium ...	,,	0·615 ,,	1·57	23·8	30·9	36·1	41·6	31·5	35·1	45·5	243	254
		Mass of atom × 10^{24}	44·5	91·6	96·4	104·3	107·1	175·0	177	195·2	320·3	323·5

When the figures are examined closely it is observed that (1) the ratio of the absorption coefficients of any two absorbers for the same wave-length is independent of the wave-length, (2) the characteristic rays of any substance are absorbed on a higher scale by substances of lower than by substances of higher atomic weight, and (3) the absorption coefficient of any substance is proportional to the fourth power of the atomic number of that substance. Now, since we know that the absorption coefficient is proportional to the (wave-length)$^{5/2}$, we have the very general law: absorption coefficient $= CN^4 . \lambda^{5/2}$, where N is the atomic number of the absorber, and λ is the wave-length of the X-ray. The quantity C is constant over considerable ranges, but changes suddenly at critical points. For instance, the results given above are covered by putting C equal to $1{\cdot}79 \times 10^{-8}$ for all values of N from 13 (Al) to 46 (Pd), and to $0{\cdot}285 \times 10^{-8}$ for all greater values. E. A. O.

76. *Spectral Analysis of Röntgen Rays and its Application to the Case of Rare Substances.* **M. de Broglie.** (Comptes Rendus, 159. pp. 304–305, July 27, 1914.)—By a method previously described [see Abstracts Nos. 1337 and 1338 (1914)] the spectra of a few more elements are investigated. The following are the results obtained:—

Substance.	Angle of Selective Reflection from the Cubic Face of NaCl.	Wave-length ×10^8.	N.
Gallium (oxide)	13° 52′	1·35 cm.	31
Germanium (oxide)	12° 53′	1·25 „	32
Tin: ray α	5° 03′	0·50 „	50
Tin: ray β	4° 27′	0·43 „	
Antimony: ray α	4° 55′	0·48 „	51
Antimony: ray β	4° 15′	0·41 „	

A provisional determination of the wave-length of the characteristic radiation from lanthanum (139) gives the value $80{\cdot}3 \times 10^{-8}$ cm. Up to the present the author has failed to observe the characteristic rays of the K series in the spectrum of tungsten. E. A. O.

77. *Factors determining the Quality of Röntgen Radiation given off by an X-ray Tube.* **W. P. Davey.** (Phys. Rev. 4. Ser. 2. pp. 208–216, Sept., 1914.)—The object of this work was to investigate whether Cardini's law (*i.e.* that the quantity of Röntgen-rays, as measured by ionisation, is proportional to the energy expended between the terminals of a tube) is of universal application, and in addition to find out whether the state of vacuum inside the tube is able to affect the quantity of Röntgen-rays given off. An electroscope is also described, which is so designed as to be practically free from error due to natural leak. It was found that with a constant p.d. across the terminals of a tube the quantity of X-rays produced per sec. is directly proportional to the current passing through the tube. Except in so far as the state of vacuum in the tube helps to determine the current for a given voltage drop, it has no effect upon the quantity of radiation given off, at least within the ordinary working limits of a standard tube. The quantity of radiation given out by a bulb, operated by a constant source of e.m.f., is directly proportional to the energy consumed in the tube. [See also Abstract No. 1264 (1914).] E. A. O.

HEAT.

78. *Expansion of Mercury at Low Temperatures.* **C. B. James.** (Roy. Soc. Canada, Trans. 8. Ser. 3. pp. 51–58, 1914.)—The author has determined the expansion of mercury over the temperature-range —37·5° C. to 100° C. by the quartz dilatometer method. For the low temperatures a well-stirred bath of methylated spirits was used. This was cooled by a stream of air aspirated from a vessel of liquid air through a spiral of lead tubing surrounding the bath. With this arrangement the temperature could be regulated and kept steady to one-hundredth of a degree. For the range 0° to ·100° C. the expansion agrees to 8 parts in 18,000 with that obtained by Callendar and Harlow by a similar method [see Abstract No. 1081 (1914)] but is 4 parts in 1800 greater than that obtained by Callendar and Moss by the absolute method. No rapid change in expansion was found near the freezing-point. F. J. H.

79. *Thermal Expansion of Solutions of Gelatine in Water.* **A. A. Scott.** (Journ. Phys. Chem. 18. pp. 677–680, Nov., 1914.)—The expansion of 2 %, 6 %, and 10 % solutions of gelatine in water has been measured between 0° and 10°. The expansions ($\times 10^6$) at each degree from 1° to 10°, the volume at 0° being taken as 1, are: for water, —57, —98, —120, —129, —119, —99, —62, —15, 47, 124; for 2 % gelatine solution, —60, —85, —90, —80, —60, —25, 25, 80, 145, 215; for 6 % gelatine solution, 20, 45, 70, 100, 130, 170, 200, 235, 270, 315; and for 10 % gelatine solution, 30, 60, 95, 125, 160, 190, 225, 255, 290, 330.

T. H. P.

80. *Calorimetric Methods.* **W. P. White.** (Amer. Chem. Soc., Journ. 36. pp. 2313–2333, Nov., 1914.)—This is the last of a series of papers on calorimetric measurements. In the "Method of Mixtures," a precision approaching or reaching 0·1 per mille, though somewhat unusual is often desirable. The author describes its attainment as especially easy with a two-calorimeter installation which secures the convenience and high precision of differential thermoelectric temperature measurement. This is the only advantage of the two-calorimeter arrangement, the diminution of heat-loss error being largely illusory. If instead a vacuum-jacketed flask is used for the comparison calorimeter there is a gain in accuracy and convenience. The necessary temperature observations may be made as simple as with the twin-calorimeter arrangement by means of a special thermoelectric combination. A completely enclosing jacket of uniform temperature is necessary for this method; but this is no loss, as such a jacket is necessary for high precision with any method. This method is quite as effective with a jacket round each calorimeter, and therefore with adiabatic methods. The present method is especially advantageous for observations of great absolute precision and for use in cases where rapidity and facility in making varied observations are required. J. J. S.

81. *Measurement of very Low Temperatures.* **XXIV.** *Comparison of Constant-volume Hydrogen and Helium Thermometers with one another and with the*

Platinum-resistance Thermometer down to the Freezing-point of Hydrogen. **H. Kamerlingh Onnes** and **G. Holst.** (Konink. Akad. Wetensch. Amsterdam, Proc. 17. pp. 501–507, Nov. 7, 1914. Communication No. 141*a* from the Phys. Lab., Leiden.)—A direct comparison has been made between the helium and hydrogen scales by means of measurements made with a differential thermometer over a range extending from 0° to the freezing-point of hydrogen. The temperatures indicated on these two scales were also compared with those given by a Pt-resistance thermometer. It is found that at −200° the curve expressing the resistance of the Pt as a function of the temperature undergoes a marked change in direction; in this region of temperature Pt is therefore an unsuitable material for thermometric purposes, since accurate interpolations are impossible. At hydrogen temperatures, neither Pt nor Au exhibits an approximately linear variation of resistance and at such temperatures and at helium temperatures manganin and constantan are more suitable materials for the construction of resistance thermometers.

T. H. P.

82. *Ignition of Gases by Condenser Discharge Sparks.* **W. M. Thornton.** (Roy. Soc., Proc. Ser. A. 91. pp. 17–22, Nov. 4, 1914.)—The more closely the conditions of electrical ignition of gases resemble those in the explosion wave-front, the more readily will such ignition occur. These conditions, namely, high temperature and pressure and, in the case of hydrocarbons, combustion to carbon monoxide, are found to be characteristic of condenser discharge sparks, which further are of very short duration, are oscillatory, and start with ionisation or breakdown of the gas between the poles. Not all visible sparks are capable of igniting explosive mixtures, and as the limiting proportions for inflammability are approached large sparks become necessary. Mixtures of air with ethane, propane, and butane exhibit the same minimum igniting current, the curves having the parabolic form characteristic of alternating-current break-spark ignition [see Abstract No. 1557 (1914)]. With ethane, however, the minimum corresponds with the point of combustion to CO, whilst with propane and butane it lies as before midway between this and combustion to CO_2. In the case of ethane and propane and, perhaps, butane, the curve shows on its higher side a step or increase in difficulty of ignition corresponding with about 4·5 and 6·5 atoms of oxygen per mol. of ethane and propane respectively. With methane the energy required to obtain ignition is much greater than with the other paraffins; for instance, 6·5 mfd. at 100 volts instead of 1 mfd. with the heavier gases. At least 6·25 % of methane must be present for ignition to occur, and up to 10·5 % the energy of the least igniting spark remains the same, but at 11·5 % a sudden increase to 16 mfd. takes place. The mixture giving combustion to CO_2 is passed without change; combustion to CO is at 12 %. At 13 and 13·5 %, 40 mfd. have to be used and at higher percentage no ignition could be obtained with the 46 mfd. available. The sparks were then very bright and pitted the poles freely. Similar steps are exhibited by the curves for mixtures with air of carbon monoxide, hydrogen sulphide, and hydrogen. This increased resistance to ignition is probably due to the fact that when an atom of combustible gas, or of oxygen in some cases, is surrounded by molecules with one or more of which it is eventually to combine, the difficulty of choice of any single partner is increased by the simultaneous attraction of the others, and more energy must be imparted to the gas to set up a movement so violent that any pair is forced into "contact." In some instances, for example, with CO,

the difficulty of ignition becomes acute only in certain aggregates, the steps being at 3, 6, and 9 mols. of CO per one of O_2. With methane, they are when 3 or 4 mols. of oxygen are present to 1 of the hydrocarbon, and with hydrogen the critical ratios of hydrogen mols. to oxygen atoms are 1, 2, 3, and 6. With carbon monoxide the energies of ignition of the two stages are 0·0082 and 0·018 joules, the ratio being 1 : 2·19, there being twice as many mols. of CO in the second case. In methane the values are 0·032, 0·8, and 2 joules, the ratios being 1 : 2·5 : 6·25 ; in hydrogen sulphide, 0·007, 0·01 and 0·0195 joule, which are in the ratios, 1 : 1·43 : 2·79 ; and with hydrogen, 0·00025, 0·00095, 0·0016 and 0·0030 joule, which are in the ratio, 1 : 3·8 : 6·4 : 12·0. The ratios of the energies in successive stages thus increase approximately in the constant ratio 2, the difficulty of ignition being, on the average, doubled at each step, although the number of molecules in contact with a combining atom is not as a rule doubled. T. H. P.

83. *Least Energy required to Start a Gaseous Explosion.* **W. M. Thornton.** (Phil. Mag. 28. pp. 734–738, Nov., 1914.)—The author compares the energies of the least igniting break-sparks of continuous and alternating current with those of condenser discharge between Pt poles as a standard. Since, with mixtures of CO and air a ring of carbon is deposited round the point of contact of the poles after the passage of sparks which do not cause explosion, it seems possible that there is no true combustion until explosion occurs, and that gas does not aid ignition but at first retards it by the absorption of energy in breaking down the combustible molecules in contact with the spark. When the time-constant, L/r, of an electric circuit is always the same, as is the case if the same type of resistance is used throughout, the energy, $\frac{1}{2}Li^2$, of the break-flash is proportional to the power of the circuit ; in the conditions employed, the time-constant, c, is 0·0016 sec. The igniting power of a break-flash, measured by the ratio of the current to the number of atoms of combustible gas in unit volume, has been found to vary with continuous currents inversely as the cube of the voltage [see Abstracts Nos. 1557, 1692 (1914)], other factors being constant. When the latter are varied there will be a component of the current which will change as V^{-3} and one of the corresponding power, Vi, as V^{-2}.

With continuous currents at voltages of 100–200, the least igniting energy for poles of Fe, Ni, and Cu, ranges from 0·02 to 0·15 joule, that is, from 0·0048 to 0·036 gm.-cal. With alternating currents, the energies for the same voltages show the greatly increased values, 0·15–0·5 joule, and vary more widely with the voltage. The author's previous considerations indicate that the energy-voltage curves should consist of three parts, and this conclusion is in such good agreement with the observed form of these curves as to warrant the assertion that the energy required for ignition by alternating current depends almost entirely on the duration of the arc in the gas ; it is hence suggested that ignition of this type is of thermal origin. Ignition seems to depend on such a relation between the nature of the gaseous mixture and the incandescent matter projected into it from the poles that the duration of the least igniting break-spark is inversely proportional to its energy. In continuous-current ignition it is the material of the poles which is decisive, and with alternating current the nature of the gas. Also, with condenser-discharge spark ignition in which the duration is so short that heating from the spark cannot spread far before extinction, a close connection between the ignition and the nature of the gas is indicated. With condenser sparks at different voltages in the same gaseous mixture, the energy curve has a form very nearly the mean of those of the two types of break-spark.

Taking the number of molecules in 1 cm.^{3} of the gas as 3×10^{19}, energy of 0·1 joule is equivalent to the complete burning of $8{\cdot}5 \times 10^{16}$ molecules or 2·6 mm.^{3} of the combustible gas in the mixture of air and methane giving complete combustion. T. H. P.

34. *Vapour Pressures of Platinum and Molybdenum.* **I. Langmuir** and **G. M. J. Mackay**. (Phys. Rev. 4. Ser. 2. pp. 377–386, Oct., 1914.)—The vapour pressures of Pt and Mo have been determined by a method essentially the same as that previously employed [Abstract No. 907 (1914)], which consists in ascertaining the loss in weight suffered by wires of the metals maintained electrically at various temperatures for definite periods of time in glass vessels exhausted to an exceptionally high degree. The temperature-range employed was 1682–2000° K. for Pt and 1994–2373° K. for Mo. The vapour pressure in mm. of Hg at temperature T abs. is given by $\log p = 14{\cdot}09 - 27800/T - 1{\cdot}26 \log T$ for platinum and by $\log p = 17{\cdot}354 - 38600/T - 1{\cdot}26 \log T$ for molybdenum. The latent heats of vaporisation, in cals. per gm.-atom, are $128000 - 2{\cdot}5T$ and $177000 - 2{\cdot}5T$ for Pt and Mo respectively, these results being in moderately good agreement with Nernst's approximate equation, $\log p = -\lambda_0/4{\cdot}571T + 1{\cdot}75 \log T + C$, where p is the pressure in atmos., λ_0 the molecular heat of evaporation, and C is the chemical constant, which has a value of about 3 for most substances. T. H. P.

35. *Molecular Kinetic Elements of the Vapours of Isomeric Compounds.* **A. Pochettino.** (N. Cimento, 8. Ser. 6. pp. 5–36, July, 1914.)—The author has determined, by Stefan's method, the coefficients of diffusion, D, into air of the vapours of a considerable number of esters and of various other groups of structural and position isomerides. The reduction of the values of D to a common temperature was effected by means of Sutherland's formula, $D_2/D_1 = (T_2/T_1)^{3/2}.(1 + c/T_1)/(1 + c/T_2)$, in which c represents a constant characteristic of the pair of gases under consideration; better concordance is obtained by this formula than by the relation, $D_1/D_2 = T_1^2/T_2^2$, deduced from the old kinetic theory of diffusion. From the values thus obtained, those of L, the mean path of the molecules, of σ, the diameter of the sphere of molecular action, and of Q, the sum of the sectional areas of the spheres of action of the molecules in unit volume, have been calculated. As might be foreseen, increase of the number of atoms in the molecules of homologous compounds is accompanied by diminution in the mean path of the separate molecules and by increase in the diam. of the sphere of action. In the case of isomeric compounds with normal, and therefore equal, vapour densities, the molecules of the vapour differ in the diams. of their spheres of action, iso-compounds giving lower values than those of normal structure. This observation is related to the fact that, according to van't Hoff's hypothesis, the centres of the carbon atoms are nearer with iso-compounds than with normal ones. In the following series of isomeric compounds, the values of σ are in order of diminishing magnitude, whilst those of the propinquity of the carbon atoms, as judged from the steric formulæ, are in order of ascending magnitude: butyl alcohol, isobutyl alcohol, ether, trimethylcarbinol; propylbenzene, isopropylbenzene, mesitylene; butylamine, isobutylamine, diethylamine; benzyl chloride, ortho-, meta-, and para-chlorotoluenes; ethylbenzene, ortho-, meta-, and para-xylenes. With isomeric compounds of the formula $C_nH_{2n}O_2$, leaving aside the acids, σ is smallest for that isomeride in which the position

of the group, ·C·O·C·, is such that the two atomic complexes attached to the two carbon atoms are most nearly similar ; the association of the acids in the liquid state seems to influence the values of L and σ. The increase in the value of σ produced by addition of a CH_2 group varies with the molecular structure of the original compound. With the acids, $C_nH_{2n}O_2$, its mean value is $1{\cdot}12 \times 10^{-8}$, and with the isomeric esters, $0{\cdot}56 \times 10^{-8}$.

Since the value of the coefficient b of van der Waals' equation is related to that of σ according to the equation, $b = 4\pi N\sigma^3/6$, b and σ should increase together in series of isomeric compounds, and this is found to hold in general, although exceptions do occur. Further, according to the Mossotti-Clausius law, the fractional volume, v, actually occupied by the molecules of a gas is connected with the dielectric constant, K, and the index of refraction, n, for $\lambda = \infty$, by the relation, $v = (K-1)/(K+2) = (n^2-1)/3$; this method of comparing the molecular dimensions agrees with the values of σ in the case of ethyl formate and methyl acetate, but not in that of ethyl acetate and methyl propionate.

The values of L given by the diffusion method were compared, for a number of the compounds investigated, with those derived from measurements of the coefficients of internal friction of the vapours. The agreement between the two series of values is not good, but the variation observed in passing from a compound to an isomeric one is in the same direction and approximately of the same magnitude in the two series.

Measurements of the thermal conductivity of the vapours of a number of the compounds show that, in a group of isomeric compounds, the values of the conductivity and of L increase together. T. H. P.

86. *The Chemical Constant and the Equation of State of an Ideal Monatomic Gas on the Quantum Theory.* **W. H. Keesom.** (Konink. Akad. Wetensch. Amsterdam, Proc. 23. pp. 20–23, July 3, 1914. Supplement to 36*b* from Phys. Lab., Leiden.)—The author shows that the value of the chemical constant previously deduced [Abstract No. 288 (1914)] from the expansion for the entropy, is in satisfactory agreement with the values derived from the experimental results concerning the vapour pressures of monatomic gases. If for the energy distribution one of the temperature functions is assumed which occur in the quantum theory, the molecular rotatory motion, particularly for the molecules of a monatomic gas, may be assumed to be in thermal equilibrium with the translatory motion. Taking then the temperature function, given by Planck, which implies a zero-point energy, the molecular rotations in a monatomic gas also, at the temperatures at which these gases have been investigated, represent a considerable amount of energy compared with the molecular translatory motions. The characteristic temperatures which in this case govern the rotatory energy will be so high, owing to the small moment of inertia of the monatomic molecules, that, within the temperature range considered, the rotational energy will not differ sensibly from the corresponding zero-point energy, and this applies also to the intra-atomic motions. The contributions to the entropy from both sources will be negligible, and the author limits himself to the temperature-range for which this holds. The restriction of the investigation to an ideal monatomic gas eliminates the consideration of terms expressing the influence of the real volume and of the mutual attraction of the molecules. G. W. DE T.

87. *The Quantum Theory and Thermal Energy Distribution.* **G. N. Lewis** and **E. Q. Adams.** (Phys. Rev. 4. Ser. 2. pp. 331–344, Oct., 1914.)—The

authors, in a previous paper [Abstract No. 1091 (1914)], arrived at the conclusion that the Wirkungsquantum *h*, in suitable units, is simply the square of the electron charge multiplied by a numerical factor, which led to an attempt to explain the facts by less radical assumptions than those of the quantum theory, and so much of the theory as relates to partition of energy is here considered. An indefinite number of equations corresponding to Planck's can obviously be devised to fit the true distribution curve with any desired accuracy. That derived from equipartition is experimentally excluded. But it was derived by regarding an infinite number of independently moving particles of infinitesimal mass as equivalent to a continuum, which they point out to be illegitimate. The failure of the Rayleigh and Jeans radiation formula is to be ascribed to the continuity of the *Hohlraum*, not, as in the quantum theory, to its discontinuity. In the continuous *Hohlraum* the electric, or magnetic, vector at any point determines a most probable value at every point, and the probability function, a function only of the original vector, of the distance, and possibly in some cases of the average strength of the field, will determine the true energy distribution ; since the vector at any point will continue for a finite distance to have a component in the same direction. Consider a *Hohlraum* in thermal equilibrium at a given temperature and a fixed point unit where the vector has, say, a northerly component. Then the locus of termini of lines from this point to points where the N-component vanishes will form a closed surface, and the whole volume may so be divided into a finite number of domains, in each of which all electric vectors possess a N-component, or all possess a S-component. The average volume of these domains obviously depends only on T and not on the arbitrary direction. Hence, from Wien's law, the average volume varies as T^{-3}, and the average entropy of any domain is the same under all conditions of thermal equilibrium. These domains are closely analogous to Planck's *Elementargebiete*, though derived from a theory largely the opposite of a quantum theory, and are found to be of the order of 10^{-3} cm.^{3}. A *Hohlraum* must contain a considerable number in order that the instantaneous conditions may safely be treated statistically.

The equipartition law explains observed specific heats quantitatively for (1) monatomic gases, translational kinetic energy only of the atoms being assumed ; (2) most solid elements at ordinary temperatures, each atom being assumed to possess the same translational energy, and on the average an equal potential energy ; but neither the decrease of specific heat at low temperatures nor the failure of the atom to acquire rotational energy ; and the authors advance arguments against Jeans's explanation as due to non-attainment of true thermal equilibrium. The author's thesis is that : "a particle subject to no constraints acquires at each temperature the kinetic energy demanded by the equipartition theorem, but a constraint in any mode of motion diminishes the kinetic energy associated with that mode of motion, and this diminution is greater the more powerful the constraint." The quantum theory has been invoked to explain these results. The authors maintain that all the phenomena of thermal energy may be qualitatively and semi-quantitatively explained on the assumption that "in a system subject to constraints, the acceleration of any portion of the system under given conditions is less than it would be in the absence of the constraints, and that this difference increases with the acceleration. This does not mean that we must give up the law that acceleration is equal to force divided by mass, but only that in a quasi-continuum it is hard to localise the forces and masses, and that formerly we have assumed a given mass to be acted upon by a larger force than the actual one." Their contention is supported by the interesting results of its application to the observed behaviour of the specific heats of solids and of monatomic and diatomic gases, including several exceptional cases. G. W. DE T.

88. *Internal Work in Liquid Evaporation.* **R. D. Kleeman.** (Cambridge Phil. Soc., Proc. 17. No. 5. pp. 402–408, May 5, 1914.)—It is shown from results previously obtained [Abstract No. 1631 (1912)] that, treating the saturated vapour as a perfect gas, the internal heat L of evaporation of a molecule is given by $L = U + (u - u_a)$, where U is the work done against molecular attraction, and $u - u_a$ the change in internal molecular energy, u_a being the internal energy of a gaseous molecule. Therefore if the liquid undergoes a small change in density the corresponding changes in the potential energy and internal molecular energy are dU and du. Some have assumed dU and du of same order of magnitude, while van der Waals neglects du altogether in his equation of state, in which, however, it must occur [Abstract No. 308 (1913)]. The author has cited circumstantial evidence for the conclusion that du is small compared with dU [Abstract No. 1172 (1912)]. He here obtains the relation $u - u_a = .13U$, showing that, as was to be expected, the change in the internal energy of the molecule is small compared with other energy changes. This places on a sound basis the conclusions as to the law of molecular attraction derived in the author's previous papers from a study of the internal heats of evaporation of liquids. G. W. DE T.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS AND ATMOSPHERIC ELECTRICITY.

89. *Law of Induction.* **A. Blondel.** (Comptes Rendus, 159. pp. 674–679, Nov. 16, 1914.)—The author describes some experiments undertaken to settle whether we should consider an induced e.m.f. as being produced by the variation of the total magnetic flux encircled by a conductor, or by the cutting of a part of the flux by the conductor. It is considered by some that of these two causes the first is the more general and implicitly contains the second. The method of the experiments described is to produce a variation of flux by placing a coil in a constant magnetic field and unwinding it by rotation about its axis, which is in the direction of the field. Thus, if N is the number of turns in the coil and ϕ the flux through each turn, there should result, on the first supposition, an e.m.f. $= - d/dt(N\phi) = -\phi \, . \, dN/dt$. This should be capable of measurement. It is concluded that there can be an e.m.f. induced in a circuit by a constant magnetic field only when a moving portion of the conductor cuts lines of force, and not when a wire conductor is displaced tangentially to its trajectory. T. H.

90. *Atmospheric-electric Observations made on the Second Cruise of the "Carnegie."* **C. W. Hewlett.** (Terrestrial Magnetism, 19. pp. 127–170, Sept., 1914.)—The work was confined to observations of potential gradient, the specific conductivity and the radio-activity of the air. The cruise occupied 3½ years and covered the waters of the North and South Atlantic, South Pacific and Indian Oceans. Three different observers took part in the work and their methods were not in all cases identical. The same Gerdien conductivity apparatus was employed throughout the cruise, while for determining the radio-activity the method proposed by Elster and Geitel was used. On only one occasion was a negative potential gradient observed, though observations were frequently made while rain was falling. Usually during rain the gradient was very high, but it was always positive. The mean value for the conductivity λ throughout the voyage was found to be not less than $3{\cdot}25 \times 10^{-4}$ e.s. unit; the ratio of λ_{plus} to λ_{minus} was not greater than 1·2 and the mean value of the potential gradient near the surface of the water was of the order of magnitude of 120 volts per metre. The above value for the conductivity is fully half as large again as that usually found over land. The mean values obtained for $\lambda \times 10^4$ in the different oceans were: Pacific, 2·5; Atlantic, 3·5; and Indian Ocean, 4·3. The radio-activity of the atmosphere was small compared with that found over land, and no connection was apparent between the radio-activity and conductivity. The observations have been grouped with a view to tracing any connection which may exist between the atmospheric electric elements and the various metorological factors. As a rule the relations found agree with those which have previously been known to exist on land. No connection was found between the cloudiness of the sky and the conductivity, so that it is concluded that no solar or sky radiations which are cut off by the presence of clouds affect the conductivity. A useful summary is given of the results obtained by other workers on the electric conditions over the sea. J. S. Di.

DISCHARGE AND OSCILLATIONS.

91. *Photoelectric Effect in Selenium.* **O. U. Vonwiller.** (Engineering, 98. p. 611, Nov. 20, 1914. Paper read before the British Assoc., Australia, 1914.)—This is a preliminary account of experiments undertaken for the purpose of deciding whether the photoelectric effect shown by the conducting, not the vitreous, insulating selenium, depends on the mode of preparation. Selenium is prepared by distillation *in vacuo*. Temperature certainly has an influence, for selenium heated to 260° has ten times the conductivity of the substance heated to 109° only. The most effective rays in the photoelectric action are the red; the action of red rays seems to penetrate to a depth of 0·1 mm., whilst ultra-violet rays merely affect the surface. Scraping makes a difference only when there is also exposure to light. The photoelectric currents are sometimes as great as those from bright zinc. The fatigue of Se disappears again in the dark; mere exposure to the atmosphere, unless accompanied by heating, does not cure the effect. A. E. G.

92. *Contact Potentials and Photoelectric Properties of Metals* in vacuo. **A. E. Hennings.** (Phys. Rev. 4. Ser. 2. pp. 228–246, Sept., 1914.)—The plan adopted is to test, simultaneously and *in vacuo*, the contact potentials and photoelectric properties of eight of the ordinary metals (Mg, Al, Zn, Sn, Fe, Brass, Cu, and Ag), not only under conditions which have usually obtained in the study of either of these phenomena, viz., with surfaces prepared in air and subsequently surrounded by a vacuum, but also with surfaces mechanically prepared in a vacuum which was the best obtainable, and which was maintained throughout all operations, and finally to observe the time changes in contact p.d.'s and photo-sensitiveness of photoelectrically or mechanically treated surfaces. Photoelectric experiments on clean surfaces *in vacuo* have already been made, and described by Pohl and Pringsheim, and Hughes, using freshly distilled surfaces, and by Herrmann, Richardson and Compton, and Page, using mechanically cleaned surfaces. The apparatus and outline of experimental procedure is described, and details of results obtained are given in tabular and graphical form. The point of view that the so-called contact potentials are due to intrinsic properties of the metals finds substantial support on the basis of the results of the present investigation. The considerations leading to this conclusion are as follows:—(1) The metals become more electro-positive when new surfaces are prepared in the best obtainable vacuum. (2) The changes in contact p.d.'s which are observed to take place in film-coated surfaces subjected to photoelectric treatment are such as to indicate that whatever the modifications are they take place in the film and not in the metal. (3) The observed initial velocities of emission of electrons from recently prepared surfaces are nearly the same for all metals, suggesting that the more electro-positive a metal is, the greater the actual velocity of emission of electrons from its surface. (4) The apparent initial velocities of electrons are less for film-coated than for clean surfaces, and not in a manner to be accounted for by accompanying changes observed in the contact potentials. To the extent that this is not explained by the differences between the relative effects of the direct illumination and the electrons set free by reflected light for the new and old surfaces, the film acts as a mere mechanical obstruction in addition to serving as an electric screen or contributing to the electrical field. (5) The fact that the differences in the applied accelerating potentials necessary to produce the saturation currents from clean metallic surfaces under illumination coincide in a general way with those in the

observed contact p.d.'s would not be cited as evidence in favour of an electrolytic or chemical theory of contact potentials. (6) Since the photosensitiveness of the metals is much greater with new than with old surfaces, and since the order assumed by metals with clean surfaces is practically that of the contact series, it appears that the electro-positive character of a pure metal is an index of the readiness with which it gives up electrons. A comprehensive view of the above considerations shows that the facts warrant the suggestion that the contact potentials are manifestations of inherent properties of the metals, and also throw some light on what the nature of these properties may be. None of the facts are contradicted by supposing that the electro-positive or electro-negative character of the metal has to do with its ability to retain electrons or its tendency to discharge them. This is essentially the view held by Helmholtz, who conceived of the metals as having specific attractions for positive and negative electricities, the nature and intensity of the electrification displayed by a given metal representing the difference between its attractions for the two kinds. A. E. G.

93. *Production of Neon and Helium by the Electric Discharge.* **J. N. Collie, H. S. Patterson,** and **I. Masson.** (Roy. Soc., Proc. Ser. A. 91. pp. 30–45, Nov. 2, 1914.)—A continuation of previous work [see Abstract No. 1036 (1913)]. Elaborate tests have been made with special forms of discharge tube. A few of these are described with the aid of diagrams. A great many of the experiments yielded negative results, for as yet unexplained reasons. Tentative suggestions are made as to why Strutt's work proved unsuccessful, and it is noted that Strutt's results are in opposition not only to many of the results obtained by the present authors, but also to those of J. J. Thomson, which appear substantially to corroborate the authors' results by an independent method. Although the source of the neon and helium has not been as yet discovered, it appears, from careful experiments now made, fairly certain that these gases were not previously contained in the materials of the tubes; and other experiments show that permeation from the air through the walls of the discharge tubes appears to be equally improbable. A. W.

94. *Measurements in Air of Lengths of Electric Waves associated with a Thin, Straight, Terminated Rod.* **J. A. Pollock.** (Engineering, 98. p. 681, Nov. 13, 1914. Paper read before the British Assoc., Australia, 1914.)—According to Rayleigh and J. J. Thomson, the wave-length should, under certain conditions, be twice the length of the rod; but according to MacDonald (theory and experiments), the coefficient should be not 2 but 2·53. The author had obtained results in agreement with MacDonald, but more recently, using the coherer method for detecting nodes, he obtained the value 2·09, which agreed with the 2·1 of American experimenters. The theory is very difficult on account of the discontinuities at the edges of the rod, and for other reasons, but the author is unable to account for the great discrepancy between his two results. G. W. DE T.

95. *Atmospheric Refraction in Radio-telegraphy.* **J. A. Fleming.** (Phys. Soc., Proc. 26. pp. 318–332; Discussion, pp. 332–333, Aug., 1914. Electrician, 74. pp. 152–154, Nov. 6, 1914. Abstract.)—The mathematical investigations of H. M. Macdonald [Abstract No. 1313 (1914)] and of March and v. Rybczyński [Abstracts Nos. 569 (1912), 1489 (1913)] show that true diffraction can account for part only of the effect at the distant receiving station. Some part appears also to be transmitted along or through the earth's crust, but that this cannot

be the major part is shown by the influence of atmospheric changes in respect to solar illumination. Observation points to some continually fluctuating atmospheric condition as a principal factor. The author here deals with the conditions under which true atmospheric refraction would be sufficient to carry radiation emitted horizontally from any point on the earth's surface round the earth parallel to the surface. W. H. Eccles [Abstract No. 109 (1913)] has provided the foundation for a valid theory of ionic refraction on the basis of the theoretical conclusion that in ionised air the velocity of long electric waves is increased. And the upward decrease in atmospheric density decreases the refractive index, and so increases the velocity. Formulæ are obtained expressing this variation of density with height, including the effect of the known temperature variation, and it is shown that at a height of 100 km. the earth's atmosphere must consist substantially of H and He. An expression is then obtained for the radius of curvature at any point of a light-ray emitted horizontally from the earth's surface, its value at the starting-point being given by the formula $\rho = \mu_0/(98Aq_0^2)$, where μ_0 and q_0 are the refractive index and density at the earth's surface, and A is the Gladstone and Dale constant, $(\mu_0 - 1)/q$, for the gas forming the atmosphere. From the known values of the constant for various gases it is shown that for air ρ is four times the earth's radius, for H 136 times, and for Kr equal to the earth's radius. If, then, the earth's atmosphere consisted wholly of Kr, a ray emitted horizontally would be refracted round the earth, and radio-telegraphy to the Antipodes would be possible. These formulæ are obtained in three different ways. They show further that this circular refraction would occur if the density of the earth's atmosphere were doubled, while the constant A remained unchanged, or on a planet of double the earth's diameter with an atmosphere similar to our own. On a large planet such as Jupiter, with a dense atmosphere, no ray of light emitted at or near the horizontal direction at any point could escape from the atmosphere. The considerable evidence that many lines in the aurora spectrum are due to the more volatile constituents in the air suggests the possibility that the non-valent gases Ne and Kr are manufactured by electric discharges in the rarefied hydrogen atmosphere at great heights, and that by their ease of ionisation they contribute to the production of the ionised layer required by the theories of Heaviside and Eccles to account for the actual achievements of radio-telegraphy. G. W. de T.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

96. *Mercury Resistance Standards of the International Ohm at the Russian Bureau of Measures and Weights.* **A. N. Georgievski.** (Electritchestvo, 35. 13. pp. 255–259, Sept., 1914. Paper presented at the All-Russian Electrotechnical Congress.)—The author gives a brief summary of the proceedings which have led to the establishment of the international standard and its definition, and then furnishes an account of the construction of standards. Hard French glass tubes were obtained from Baudin graduated in 1100 divisions of a mm. each. The rest of the work was done in the Bureau in Russia. It fell into three divisions: (1) The calibration of the tube; (2) determination of the mass of the mercury filling the tube at 0° C.; (3) measurement of the length of the tube at 0° C. The precautions necessary to secure extreme accuracy are fully described. Table I contains the results of determination of the length of the tubes at 0° C., the masses of the mercury

M, and the mean sections, found by Smith's method (A) and prefatory determinations of the weights and lengths of the mercury columns.

TABLE I.

No. of Tube.	Correction for Unequal Section.	Length of Tube at 0° C. in mm.	Mass of Mercury at 0° C. in gm.	A. Sq. mm.	B. Sq. mm.	B – A. 1×10^{-5}.
1	$1{\cdot}00008_6$	998·146	$12{\cdot}6308_2$	$0{\cdot}93792_3$	$0{\cdot}93791_2$	-1_1
2	$1{\cdot}00003_0$	1000·050	$12{\cdot}8024_2$	$0{\cdot}94150_8$	$0{\cdot}94152_4$	$+1_6$
3	$1{\cdot}00003_1$	977·556	$12{\cdot}2334_7$	$0{\cdot}92063_8$	$0{\cdot}92064_2$	$+0_4$
4	$1{\cdot}00005_6$	1044·477	$13{\cdot}9631_3$	$0{\cdot}98383_8$	$0{\cdot}98384_6$	$+0_8$
5	$1{\cdot}00002_1$	935·649	$11{\cdot}2085_5$	$0{\cdot}88090_8$	$0{\cdot}88091_2$	$+0_4$

The length of the tube L_0, the mass of the mercury M, and the calibration data serve to calculate the resistance of each of the standards by the formula $W_1 = 0{\cdot}01278982\, L^2_0/M\, 1/n \sum_1^n 1/\sigma_k + 0{\cdot}8/1063\pi\,(1/r_1 + 1/r_2)$. In Table II are set out the results of comparison of the standards with normal resistances Nos. 4044 and 4046 by each of two methods: K compensation, and D differential galvanometer.

TABLE II.

No. of Standard.	4044.			4046.		
	K.	D.	Mean.	K.	D.	Mean.
1	—	$0{\cdot}99968_6$	$0{\cdot}99968_6$	—	$0{\cdot}99969_7$	$0{\cdot}99969_2$
2	$0{\cdot}99998_2$	$0{\cdot}99998_6$	$0{\cdot}99998_4$	$0{\cdot}99999_6$	$0{\cdot}99999_6$	$0{\cdot}99999_6$
3	$0{\cdot}99996_8$	$0{\cdot}99997_1$	$0{\cdot}99996_9$	$0{\cdot}99997_5$	$0{\cdot}99997_2$	$0{\cdot}99997_3$
4	$1{\cdot}00010_9$	$1{\cdot}00011_1$	$1{\cdot}00011_0$	$1{\cdot}00011_6$	$1{\cdot}00011_2$	$1{\cdot}00011_4$
5	$0{\cdot}99981_7$	$0{\cdot}99983_1$	$0{\cdot}99982_4$	$0{\cdot}99982_9$	$0{\cdot}99983_1$	$0{\cdot}99983_0$

On the basis of comparison of this table with the second columns of Table III, which contain the values of W_1 for all five standards, it is possible to find the resistances:

No. 4044 $1{\cdot}00003_7$ international ohm
No. 4046 $1{\cdot}00003_1$ international ohm

TABLE III.

No. of Standard.	Calculated Resistance.	Observed Resistance.			Obs. – Calc. 1×10^{-5}.
		4044.	4046.	Mean.	
1	$0{\cdot}99970_4$	$0{\cdot}99972_3$	$0{\cdot}99972_3$	$0{\cdot}99972_3$	$+ 1_9$
2	$1{\cdot}00002_3$	$1{\cdot}00002_1$	$1{\cdot}00002_7$	$1{\cdot}00002_4$	$+ 0_1$
3	$0{\cdot}99999_3$	$1{\cdot}00000_6$	$1{\cdot}00000_4$	$1{\cdot}00000_5$	$+ 1_2$
4	$1{\cdot}00017_0$	$1{\cdot}00014_7$	$1{\cdot}00014_5$	$1{\cdot}00014_6$	$- 2_4$
5	$0{\cdot}99987_2$	$0{\cdot}99986_1$	$0{\cdot}99986_1$	$0{\cdot}99986_1$	$- 1_1$
					Mean $\pm 1_3$

In Table II the resistances are expressed in values of corresponding manganin resistances at a temperature of 18°. In the last column of Table III are included the differences between the observed means and the calculated resistances—the so-called "residual error." **E. O. W.**

97. *Determination of the International Ampere and Volt by Aid of the Silver Voltameter and Weston Standard Cell in the Russian Bureau of Measures and Weights.* **A. B. Feringer.** (Electritchestvo, 35. 13. pp. 260–263, Sept., 1914. Paper presented at meeting of the All-Russian Electrotechnical Congress.)—Up to 1908 the Clark standard cells prepared by M. V. Ivanoff had been used. Subsequently it was resolved to investigate the properties of the Weston cell with a view to its adoption as a Government standard. The author recounts his researches into the purity and constancy of the necessary constituents. The work done by Bijl, of Amsterdam, and F. E. Smith in England on the amalgam is referred to, as well as investigations carried out in America.

The construction of a number of cells in Russia has been very successful. Some have been brought to England and compared with the standards of the National Physical Laboratory. At the present time in the Russian Bureau there are 87 elements, the e.m.f.'s of which correspond within a hundred-thousand parts of a volt. Each three to four months all the elements are compared among themselves and with standards—for instance, Nos. 5 and 7 which were standardised with the silver voltameter both in Russia and at the N.P.L. in England.

The following table exhibits, using No. 7 as the standard of reference, the constancy and degree of precision attained :—

$E_7 - E_x$ in Volts × 10^{-5}.

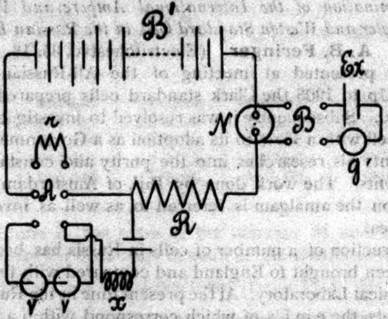
Elements.	1910.	1911.	1912.
12	0·0	+0·3	—0·5
13	—0·6	0·0	+0·8
23	+1·4	+1·6	+1·6
24	+1·6	+1·7	+2·1
27	—0·1	+1·4	+1·5
28	+2·3	+6·5	+6·9
36	0·0	—0·4	—2·0
K_5	—	+1·0	—
1	—	—8·4	—6·0
5	—	—7·1	—7·0
8	—	—5·9	—3·0

For the element E_7 the results of tests with the silver voltameter are, at 20° C., as follows :—

In England, Sept., 1910	1·01826
„ Russia, Feb., 1912	1·01827
„ „ March, 1912	1·01831
„ „ Dec., 1912	1·01834

By comparison with the Washington standards the Russian cells No. 5 and 7, the former of which is used as a control, showed the following small differences in volts × 10^{-5}: No. 5, −1·1; No. 7, −1·1; while of others kept in the Bureau, No. 26 differed from Washington in volts × 10^{-5} by 0·2 and No. 27 was exact.

Tests with the silver voltameter are carried out according to the scheme shown in the Fig.



Battery B is composed of accumulators at 110 volts; R is a regulating resistance of 110 ohms conveniently sub-divided; N is a standard ohm; VV are voltameters; *v* is a resistance approximately equal to that of the voltameters; *x* a chronograph on the tape of which the time of current flow is noted, and *g* is a galvanometer whose deflection can be observed by a glass, 1 mm. being equivalent to 0·0001 amp. Results obtained among others are shown below:—

Time	4377·68 secs.	R	0·99997 ohm.
A_I	4·984570 gm.	E_I	1·01844 at 16·15°
A_{II}	4·984404 gm.	E_{II}	1·01840 at 16·15°

The standard of reference on the same date, E_t, was 1·01829 volts.

E. O. W.

98. *Silver Voltameter.* **E. B. Rosa, G. W. Vinal, and A. S. McDaniel.** (Bureau of Standards, Bull. 10. pp. 475–586, July 15, 1914.)—A series of experiments has been carried out with the primary object of obtaining complete data to formulate specifications, according to which the voltameter might be used at any time for the measurement of current and (with the aid of resistance standards) for checking the constancy of the Weston normal cell. The voltameters used were the porous cup and Smith form, which were found to be in substantial agreement and give the value 1·01827 int. volts for the Weston normal cell at 20° C. A study of the effect of acid in the voltameter has shown a quantitative relation, expressed by the equation $y = -4{\cdot}5x + 0{\cdot}02x^2$ to hold between the acidity of the electrolyte (x) and the resulting decrease in deposit (y), both expressed in parts per million. The relation only holds when the electrolyte is pure. Iodeosine was used as an indicator and was proved to be sufficiently sensitive to detect about 1 part of acid in 8 million parts of water. The influence of septa other than filter-paper has been studied, and porcelain porous pots when properly prepared and used were found to be a safe and efficient separator of anode and kathode. Experiments were made to determine possible errors due to inclusions, and the

results lead to the conclusion that when pure electrolyte is employed no appreciable inclusions exist. With regard to the reversibility of the voltameter some careful experiments were made and the conditions found under which the instrument may be said to be reversible so that the current may be measured by the loss of the anode as well as the gain of the kathode. As a general conclusion the authors state that the silver voltameter has shown itself to be an instrument of precision and capable of checking the constancy of the Weston normal cell. The following table gives some results of recent values for the cell :—

Date.	Observations.	Voltameter.	Number of Deposits.	Value for Cell.
1908–9	First series, Bureau of Standards	Porous cup	42	1·01828$_7$
1909–10	Second series, Bureau of Standards............	Small porous cup	44	27$_5$
1910	International Technical Committee..............	Porous cup	14	28$_6$
1910	International Technical Committee..............	Smith's form	8	28$_7$
1910	Smith and Vinal at Teddington	Porous cup	15	21$_8$
1910	Smith and Vinal at Teddington	Smith's form	19	30$_4$
1911–12	Third series, Bureau of Standards	Porous cup	156	26$_7$
1911–12	Third series, Bureau of Standards	Smith's form	55	27$_4$

Porous cup, mean of 271 determinations.............. 1·01827$_0$
Smith's form, „ 82 „ .... 1·01828$_2$

[See Abstracts 501 and 675 (1913).] F. E. S.

99. *Approximate Determination of the Resistance of an Irregular Conductor.* **J. F. H. Douglas.** (Phys. Rev. 4. Ser. 2. pp. 391–395, Oct., 1914.)—The author points out the connection between a method developed by L. F. Richardson [Abstract No. 458 (1908)] for drawing a field of force or current and estimating resistance, and a principle given by Rayleigh. At present in finding the resistance it is often assumed that the lines of force are arcs of circles, straight lines, involutes, etc. This arbitrary assumption so cramps the field that the resulting resistance is too high. The author shows how to calculate the resistance of an irregular two-dimensional conductor for any assumed flux which can be expressed analytically. As an example the leakage field of force between the circular poles of a dynamo-electric machine is taken. Assuming the lines of force to be sine curves the values of the leakage permeance are obtained for various values of pole diameter and pole-pitch and compared with those derived from Pohl's formula. An error of 90 % is noted in present methods of computing permeance in dynamo-electric machinery. T. H.

100. *Electrical Resistance of Thin Metallic Films.* **W. F. G. Swann.** (Phil. Mag. 28. pp. 467–496, Oct., 1914. Paper read at meeting of the British Assoc., Birmingham, 1913.)—According to O. W. Richardson [Abstract No. 925 (1912)], the theory which attributes electrical conduction to the presence of free electrons requires, in order that the variation of the resistance of a metal with temperature shall be explained, that the mean free path of an electron shall vary as T^{-3}, and not as T^{-1} as hitherto supposed. Patterson [Abstract No. 824 (1903)] has shown that the specific resistance of thin films is abnormally high and increases enormously as the thickness decreases below a certain critical value. J. J. Thomson has shown that this can be accounted for as arising from a diminution in the free paths of all electrons having a component of motion transverse to the thickness when this is small enough to be comparable to the normal free mean path, with a corresponding diminution in the acceleration due to the electric field. A number of films were deposited by sputtering from a Pt kathode *in vacuo*, all the films in any one set being deposited in the same vacuum, so ensuring greater uniformity of deposition than was attainable by Patterson's procedure. The resistances were measured at 99·8° (in steam), 18·9° (in water), and —180° (in liquid air), and curves were plotted with the times of deposit, taken in measuring the thickness, as abscissæ, and the ratio of apparent to specific resistance as ordinates. According to the above theory the curve should be practically hyperbolic, and the distances of the bends from the origin of thickness for the first and last series should be in the ratio of unity to 8·58. Actually the three curves were practically coincident at the bend, as the increase of resistance at the critical point was enormously greater than theoretically anticipated. Further, it was found that with a rise in temperature the specific resistance increased slightly for thick films, and decreased rapidly for thin films. In the case of films of intermediate thickness, the temperature coefficient showed a reversal of sign over the temperature range employed. The author shows by comparison of the observed results with those of analysis given in the paper that the following hypotheses provide a first approximation to a theory :—(1) That the molecules are deposited in groups covering the plate for a time of deposit less than that corresponding to the critical value. (2) That they are not pressed into intimate contact, and that it is only those electrons which have more than a certain minimum velocity, depending on the closeness of packing, which can travel from one group to the next. (3) That this necessary velocity gets less as the time of deposit increases and the groups are pressed more intimately into contact by the greater molecular forces brought into play. The effect of the electric field then has to be considered as that of accelerating the electrons which are travelling against the field, and retarding those travelling in the opposite direction. G. W. de T.

101. *Experiments with Liquid Helium. Imitation of a Molecular Current.* **H. K. Onnes.** (Konink. Akad. Wetensch. Amsterdam, Proc. 23. pp. 12–20, July 3, 1914. Communication No. 104*b* from Phys. Lab., Leiden.)—If a current is generated in a closed supra-conductor from which no other work is required than what is necessary to overcome the possible remaining micro-residual resistance of the conductor, it follows from the small value that the micro-residual resistance can have at the most, that the current will continue for a considerable time after the e.m.f. that set it in motion has ceased to work. The time of relaxation T in which the current decreases to e^{-1}th of its value is given by the ratio L/r of the self-induction L and the resistance r of the circuit. When r approaches zero this period may rise to very high values. Instead of T being of the usual order of $\frac{1}{100000}$th of a second, when the resistance of the supra-conductor becomes 1,000,000,000

times smaller the disappearance of the current may take place very slowly. The persistence of the current was demonstrated by the author by using a coil of lead wire which was cooled to a temperature of 1·8° K. in liquid helium. The micro-residual resistance at this temperature was found to be 2×10^{10} times smaller than at the ordinary temperature and thus the relaxation time is of the order of a day, as the value of T in ordinary conditions was calculated as about $\frac{1}{10000}$th sec. The coil was closed by fusing the ends and the current was started in it by induction. The coil was kept in a cryostat, and the action of the current observed by means of a compass needle. During an hour the current was observed not to decrease perceptibly. During the last half-hour the coil was no longer at 1·8° K. but at 4·25° K., the temperature of helium boiling under normal atmospheric pressure. The experiment shows that a current when started in a supraconducting wire continues to flow. When the coil is lifted out of the helium the current is instantaneously destroyed. J. J. S.

102. *Experiments with Liquid Helium. Persistence of Currents in Supraconducting Circuits.* **H. K. Onnes.** (Konink. Akad. Wetensch. Amsterdam, Proc. 17. pp. 514–519, Nov. 7, 1914. Communication 141b from the Phys. Lab., Leiden.)—An experiment was made to prove conclusively that the magnetic moment of the coil previously described [see preceding Abstract] is really caused by a current. On either side of the place where the windings of the coil were sealed together, and close to it, two wires were fixed which led to a ballistic galvanometer. Between these points of attachment the current could be cut through under helium. The coil was cooled to 2·4° K. in a field of 200 gauss by helium evaporating under reduced pressure. The current was again produced through induction by removing the field. When the compass needle with the compensation coils was arranged as before beside the cryostat a moment corresponding to a current of 0·36 amp. was registered. The observation was continued for an hour in which the diminution of the current in 45 mins. was within the limits of probable error of the measurement (2 %); after this the circuit of the coil was cut through. The needle of the compass fell back to a deviation that corresponded to a current of 0·05 amp. in the coil. The ballistic galvanometer (with a negligible self-induction and with 2000 ohms in circuit) showed an electrokinetic momentum Li of 300,000, hence as $L = 10^7$ a current of about 0·3 amp. flowed in the coil. The remaining moment is again the same fraction of the principal effect as was observed previously. It was extinguished so soon as the coil was pulled up above the liquid helium.

The experiment proves conclusively that a current does really flow through the coil. An account is then given of the observation of persisting Foucault currents, and of the arrangement of a supra-conducting key. Experiments which were made with a thick lead ring instead of a coil confirmed the supposition that the threshold value of current strength of a conductor is mainly a threshold value of current density for the material of the conductor. J. J. S.

103. *The Temperature Coefficient of Resistance of Metals at Constant Volume, and its bearing on the Theory of Metallic Conduction.* **C. A. Kraus.** (Phys. Rev. 4. Ser. 2. pp. 159–162, Sept., 1914.)—The author points out that if the conduction of the current by metals is due to electrons having a considerable freedom of movement, then, other factors remaining equal, the resistance should increase with rising temperature, since the frequency of collision increases with the temperature according to the kinetic theory. The observed resistance-change, however, is a resultant effect of all factors concerned, among which are included effects due to volume-change. With decreasing volume, the number of collisions per unit of time will increase, and the resistance will therefore increase. In most cases, however, the resistance actually decreases, and this must be due to a disproportionate increase in the number of carriers. In determining the influence of volume-change on the number of carriers present, the obvious course is to determine the resistance of the metal at different temperatures, keeping the volume constant. The temperature coefficient of resistance of a metal at constant volume is given by the equation—

$$\frac{\partial R/R}{\partial T}=\frac{dR/R}{dT}-\frac{\partial R/R}{\partial p}\cdot\frac{\partial v/v}{\partial T}\Big/\frac{\partial v/v}{\partial p}.$$

The values of the last four coefficients have previously been measured in the case of liquid mercury at 20°. From these the author calculates the value of $(\partial R/R)/\partial T=-6{\cdot}9\times 10^{-4}$; that is, the resistance at constant volume *decreases* with rise of temperature. This result points to the fact that the increase of resistance of liquid mercury with rise of temperature is due to its decrease in density. It also follows, that at constant volume, the number of carriers in liquid mercury increases with the temperature. From the effect of density on the conductance of mercury, the author concludes that only a small fraction of the atoms of liquid mercury are ionised, and furnish carriers of the current. The author points out the need of considering the question of equilibrium between the charged carriers in a metal and the neutral atoms, in order to obtain any theory of metallic conduction founded on the kinetic hypothesis. But much more work requires to be done first. A. F.

104. *Characteristics of Contact Rectification with a Silicon-Carbon Contact.* **R. C. Hartsough.** (Phys. Rev. 4. Ser. 2. pp. 306–314, Oct., 1914.)—During the last few years much experimental evidence has been brought to bear upon the phenomenon that a large current will pass in one direction and only a small current, if any at all, in the opposite direction through contacts of certain dissimilar solids [see Abstracts Nos. 1431 (1912), 1126 (1914)]. There are many unsettled and disputed problems connected with contact rectification. The question as to whether we are dealing with a film effect, the chemical or physical structure of certain materials, or the mere ease of giving up electrons has received attention. Among the uncertainties three are very much in evidence: (1) the direction of current flow is different with various voltages; (2) various points on the materials lack rectifying properties and often different points on the same specimen rectify in opposite directions; (3) the rectifying property is lost by increasing the voltage a very slight amount.

The author considered previous work and concluded that to make any real additions to former investigations a more perfect pair of contacts would have to be found. From the standpoint of convenience and accuracy it appeared that, if a rectifying contact could be found which would stand up against from 5 to 10 volts and give 0·5 to 1·0 amp. rectified current, a better position would be secured from which to study its characteristics. An important feature of the proposed contact would be the durability of its surfaces, as well as permanency of the adjustment of contact of its surfaces. With the above conditions in view, and a long list of metals and non-metals, a selective arrangement was devised. All substances which allowed more current to pass from than to the substances were put in Class A, and the opposite in Class B; those uncertain in action were placed in another series. After the three series had been carefully worked over, cross-testing was carried on involving the use of both alternating and direct current in each of about 1000 pairs of contacts tested. It was found that a silicon-carbon contact most nearly fulfilled the proposed ideal conditions for a contact as outlined above. The silicon was mounted in molten type-metal in a brass cup container. The arc-carbon electrode was insulated from the containing case by a rubber ring, and its pressure on the silicon was adjusted by a screw. Two methods of connection were employed, with four contacts: (1) the aluminium valve rectifier; (2) the mercury arc rectifier.

Slight unsteadiness was noticed when the temperature was about 300° C., but aside from this, temperature seemed to have no effect whatever. There is reason to believe that the unsteadiness was due to expansion in the metals or a change in pressure caused thereby. No effect was noticed when the contact was placed in a vacuum of 1 mm. pressure. It apparently worked as well as when in the normal air pressure. The surfacing of the silicon required some attention. The grinding was done on a carborundum wheel, but the important finishing process on a thick plate glass, using alcohol and carborundum powder to bring it to as perfect a plane surface as possible. A high polish was found not to be the best. The surfacing of the carbon was essentially the same. All surfaces were made chemically clean and dried thoroughly.

It is hard to make even a good estimate of the amount of surface in contact after using the best of care in preparation and manipulation. However, two points applied gave approximately twice the magnitude of rectified current that one point gave. Also two pairs of surface areas, surfaced exactly the same way, one area being only a little over twice that of the other, gave approximately twice the rectified current, leading to the conclusion that the magnitude of the rectified current is approximately proportional to the area of contact.

The following table relates to this point :—

Carbon Area, Cm.².	Force in Gm.	Rectified Current. Amps.
One point	30	0·050
Two points	30	0·095
1·34	50	0·115
3·44	100	0·050

Five volts alternating current used throughout test.

The character of the surface of both the silicon and the carbon is so closely connected with rectification that a very thorough study of the surfaces was carried on. Many degrees of fineness of grinding compounds were experimented with to ascertain to what extent the smoothness of surface affected rectification. A number of photographs of the surfaces used accompany the paper.

After studying the photographs of the surfaces, the author is led to think that the contact rectification takes place through the action of small points. Pressure brings more points into contact, but increased pressure does not increase the rectifying properties of a surface. It evidently has a crushing effect on surface points, destroying rectification. The author has conceived the theory of a forming process in which points very close yet not active as rectifiers are brought into contact by increased voltage, causing an arc. This is compatible with the fact that two surfaces which have been "formed" have, when separated, to be "re-formed." A surface once "formed" will be constant so long as it is undisturbed.

In the portion of the experimental work on current-e.m.f. data an effect was noticed which started a search for a time element in the rectifying action. This effect was the fact that a rectifier which would give complete rectification with an alternating e.m.f. would allow with equivalent value of direct e.m.f. as much as 15 to 20 % of the current to pass in the high-resistance direction

That pressure is closely related to rectification is known, but no one has shown the exact relation. The following readings are characteristic of many taken. They show the effect of pressure not only upon rectification but also upon the potential drop. The conditions were : (1) Same voltage throughout (5 volts alternating current). (2) Same contact area (3·44 cm.²).

Volts P.D. Contact.	Estimated Rectification Ratio.	Force in Gm.
4·25	200 : 1	25
3·85	500 : 1	50
3·70	400 : 1	100
3·65	400 : 1	150
3·60	375 : 1	200
3·55	350 : 1	250
3·50	325 : 1	300
3·40	300 : 1	400
3·15	250 : 1	800
3·00	200 : 1	1200
2·80	100 : 1	1600
2·25	50 : 1	2000

A number of oscillograms are reproduced. H. H. H.

105. *The Seat of Light Action in Selenium.* **F. C. Brown** and **L. P. Sieg.** (Phil. Mag. 28. pp. 497–508, Oct., 1914.) — Experiments made on large crystals of selenium seem to indicate that the conductivity is distributed throughout the crystal and that the change of conductivity acts throughout the crystal. The results obtained show (1) that the charge of resistance by light is a property of the crystal and not an action taking place at the contacts. (2) Illumination at different points along the crystal produces approximately the same effect at all places. (3) The crystal is changed in conductance by approximately the same amount whether the illumination is on the side of the contacts or on the opposite side. Further experiments led to the conclusion that as no light goes through the crystal, the crystal conductivity is controlled by sympathetic centres located throughout the crystal. It was found that the actions of two separate illuminations overlap just the same as if they had impinged at the same spot. There appear to be light-sensitive parts along the crystals which control the conductivity mechanism of the selenium. For the greatest effect was produced in a crystal examined when the illumination was at the end of the crystal farthest from the electrodes, a distance out of 6 mm.

Further studies of the phenomena observed are to be undertaken. J. J. S.

106. *The Time Factor in Selenium Resistance.* **G. E. Grantham.** (Phys. Rev. 4. Ser. 2. pp. 259–266, Sept., 1914.)—Experiments were made on the

recovery of the selenium cell during the fractional part of a second following exposure. A rotating disc was used from which sectors were cut to allow the light to fall upon the cell which was in one arm of a Wheatstone bridge, and a galvanometer was connected in the bridge circuit a known time-interval after exposure. A Nernst lamp and a Welsbach burner were used as sources of illumination. Curves showing the resistance at successive intervals were obtained. Frequently a negative loop was obtained, apparently indicating that the resistance of the cell a short time after exposure was less than when the cell was actually exposed to the light. The author explains the results by assuming that selenium consists of three components, A, B, and C, which under the action of light change according to the reaction: $A \rightleftarrows B \rightleftarrows C$. Assuming that the resistivity of the component A is infinite, that of B approaches the resistivity of metals, and that of C has a value near that of A. Assuming, further, that the component A changes to B at the rate a_1, B changes to C at the rate b_1, that the respective reverse rates are a_2 and b_2 and that the rate a_1 is much greater than b_1, then for a very short exposure some of A changes to B, but very little of B changes to C. During the recovery period between exposures (approximately 30 times as long as the time of exposure) some of C will change to B and some of B will change to A, but as the recovery rate is slow compared to the changing rate for one exposure, so for very short repeated exposures there will be a larger transformation to B than for longer repeated exposures. The resistance of the selenium cell depends upon the amount of B present and, consequently, for a time the rate of change should be greater for short exposures. J. J. S.

107. *Volta-effect.* **A. E. Hennings.** (Phys. Rev. 4. Ser. 2. pp. 247–251, Sept., 1914.)—A discussion of Sanford's reply to a critique by the present author on the nature of the Volta-effect. [See Abstract No. 1725 (1913).]

E. H. B.

108. *Thermo-elements of Precision.* **W. P. White.** (Amer. Chem. Soc., Journ. 36. pp. 2292–2313, Nov., 1914.)—Various practical details in the construction and use of thermo-elements are considered. Inhomogeneity can be rendered practically negligible in copper-constantan thermo-elements used for any precision up to 50 parts per million. Details of the tests necessary to secure accuracy are dealt with in the paper and it also describes in detail the methods of insulation, enclosure, and calibration. Constantan wire for thermo-elements is now obtainable in continuous lengths which vary (in e.m.f. against copper) less than 0·0002 with errors of less than 20 per million in the sensitive thermo-elements.

The more sensitive combination of several couples is generally preferable to a single couple even for rougher measurements. J. J. S.

109. *Leakage Prevention by Shielding, especially in Potentiometer Systems.* **W. P. White.** (Amer. Chem. Soc., Journ. 36. pp. 2011–2020, Oct., 1914.)—An insulation resistance equalling or exceeding 5000 megohms is often necessary to prevent serious disturbance of thermoelectric measuring systems from stray currents of power or lighting circuits, while the resistance-measuring system, which is frequently more sensitive, is in greater danger still. All such trouble may be absolutely prevented by the use of an equipotential shield, which is merely a connected system of metallic plates, wires, etc., which interposes itself at every point of solid contact between the measuring system and external bodies. The shield need not, and preferably should not, be earthed. In slightly modified form, such a shield is useful in

electric furnaces, in measurements or power circuits, and within the potentiometer circuit itself. The arrangements are easy to instal and test and mostly require no subsequent attention. [*Erratum*, Ibid. p. 2480 Dec., 1914.]

T. H. P.

110. *Sensibility Curves of Photoelectric Cells.* **H. E. Ives.** (Astrophys. Journ. 40. pp. 182–186, Sept., 1914.)—The author has previously shown that the illumination-current relationship in the ordinary forms of gas-filled photoelectric cells is not rectilinear. [Abstract No. 1888 (1914).] It is to be expected from the work of Pohl and Pringsheim [Abstract No. 1987 (1913)] that the sensibility curve will depend upon the surface and the angle of incidence, since upon these factors will depend the relative amounts of normal and selective effect. It was thus sought to find a method of preparing cells of similar surface characteristics which would be alike and reproducible. The wave-length sensibility curves of nine potassium cells were measured, and the results for five of them are reproduced as curves. No two curves are alike, either in position of maximum or in long-wave limit, and the differences can only be characterised as enormous. As a result of the investigation a caution is given regarding the use of these instruments as at present constructed, for stellar and other photometry. C. P. B.

111. *Production of Temperature Uniformity in an Electric Furnace.* **A. W. Gray.** (Bureau of Standards, Bull. 10. pp. 451–478, July 15, 1914.)—Earlier methods of obtaining uniformity of temperature within electric furnaces were unsatisfactory inasmuch as the uniformity was only obtained at one particular temperature. In the author's method an iron tube is wound longitudinally with constantan strip which is heated electrically. The two halves of the strip winding are connected in parallel, the advantages of this method of winding being (1) that irregularities in the resistance of the heating strip are distributed in such a way as to produce the minimum effect on the longitudinal distribution of temperature, and (2) the winding is made non-inductive in such a way that there is less danger of arcing by accidental contact than in the ordinary form of non-inductive winding. The ends of the furnace are closed by means of double plugs consisting of two blocks of a good heat-conductor separated by a layer of a good insulator. These plugs are heated by means of independent heating coils wound in grooves in the outside, conducting block. The whole arrangement is suitably lagged by means of asbestos cloth and asbestos-magnesia compound in the ordinary way. A furnace of this type requires a considerable time to attain thermal equilibrium, but at 145° C. the temperature only varied by 0·08 deg. C. over a length of 30 cm., while at 667° C. the variation was only 0·37 deg. C. In order to get the best results it is necessary that the temperature of the end plugs should be not far removed from that of the centre of the furnace. F. C. A. H. L.

112. *Moving-needle Galvanometer, free from Magnetic Perturbation.* **L. Puccianti.** (N. Cimento, 8. Ser. 6. pp. 64–76, July, 1914.)—By a quartz fibre is suspended a short arm carrying the mirror. From one end of this arm, by another quartz fibre, is suspended a magnetic needle so that one pole is vertically over the other. Thus the earth's horizontal component of magnetic field exerts no directive influence on the suspended system, neither does any accidental variation in the neighbourhood of the galvanometer. The reversal of polarity of a strong electromagnet in its neighbourhood did not affect the position of the mirror. One of the poles of the suspended magnet is situated at the centre of the galvanometer coil. The weight of the needle is counter-

poised by a weight at the other end of the arm which carries it. The stability and sensitiveness of the galvanometer are discussed. S. G. S.

ALTERNATING CURRENTS AND MAGNETISM.

113. *Change of Resistance of Pure Iron in Magnetic Fields.* **R. A. Heising.** (Phys. Rev. 4. Ser. 2. pp. 315–324, Oct., 1914.)—The material used was electrolytic iron of great purity, drawn into wires 40 cm. long and annealed at 700° C. It was tested longitudinally and transversely, and the following results are given:—Electrolytic iron has slightly greater ΔR/R for the longitudinal effect than ordinary iron. Iron when transversely magnetised does not increase in resistance in small fields, but continually decreases. The decrease of resistance in transverse fields after saturation is proportional to the internal field raised to the 0·85 power. [See also Abstract No. 574 (1912).] G. E. A.

114. *Magnetic Qualities of Stressed Iron and Steel.* **C. M. Smith** and **G. W. Sherman, Jr.** (Phys. Rev. 4. Ser. 2. pp. 267–278, Sept., 1914.)—Rail steel, wrought iron, mild steel, and silicon steel were tested in the form of rods 60 cm. long and 1 cm. in diam. These were clamped vertically in the testing machine, and were surrounded by the magnetising coils of a Burrows compensated permeameter. B-H curves are given for the specimens under no load, 500 kg., and 1000 kg. load (in one case 2500 kg.), the stresses being both tension and compression. B is reduced by stress, the greatest reduction of B under stress being noted in wrought iron and silicon steel under compression. In high fields the effect of stress almost disappears. G. E. A.

115. *Permanent Magnetism of Certain Chrome and Tungsten Steels.* **M. B. Moir.** (Phil. Mag. 28. pp. 738–748, Nov., 1914. Electrician, 74. pp. 385–386, Dec. 25, 1914. Abstract.)—All the specimens examined were in the form of cylindrical rods about 20 cm. long and 0·9 cm. in diam. [see Abstract No. 469B (1913)]. The six chrome steel specimens I, II, III, IV, V, and VI, contained respectively 1, 4·05, 8, 12, 16, and 20 % Cr. Each specimen is quenched at 900° C. in water at room temperature. The hysteresis curve is then obtained with a magnetometer. The max. field, which is sufficient to produce saturation, is then applied once more, and the field having been gradually reduced to zero the residual magnetism is noted. The value of the residual magnetism obtained in this way is much less than that obtained from the hysteresis curve, owing to the demagnetising influence of the ends of the magnet—an influence for which corrections are made in obtaining the absolute values of I and H belonging to the hysteresis curve. The specimen is now subjected to (*a*) percussion and (*b*) alternations of temperature between 100° C. and room temperature, until a constant state is reached. When examined at the end of one month 4 specimens had remained unaltered while 2 had altered slightly. On repeating (*a*) and (*b*) no further change could be detected. Three or four months later the magnetic condition was still constant. III gives the strongest magnet, but if retentivity is the first consideration IV is better. Four tungsten steels A, B, C, and D, containing respectively 2·88, 5·85, 8·72, and 11·65 % W, were tested in a similar manner. In addition to the tungsten these steels contain 0·48 % C and about 0·25 % Mn. By percussion and temperature alternations each loses about 8·7 % of its magnetism. At the end of one month the additional loss was 0·25 %. Neither percussion nor heating affected them further. The residual magnetism of A, B, and C was about 472, while that of D was 448;

the coercive force in each case was nearly 35·0. All these specimens are much superior in magnetic intensity to the best of the chrome steels. The similarity in the results obtained for the four specimens is remarkable.

I. W.

116. *Subsequent Magnetism of Iron.* **A. Bernini.** (N. Cimento, 7. Ser. 6. pp. 379–389, June, 1914.)—Further experiments [see Abstract No. 590 (1912)] on two samples of Swedish iron show that for strengths of field up to 20 units the law of the variation of the subsequent magnetism is represented well by the expression $\phi = A(1 - e^{-\lambda t^{1/3}})$. For very feeble fields—less than 0·5 unit—the values of λ are smaller for a bundle of wires than for a bar of the same mass and material, whilst for more intense fields the reverse is the case. The variation of λ with weak fields is in good agreement with the equation, $\sqrt{B} = k\lambda$, where B is the strength of field and *k* a constant depending on the conditions of the specimen; for intense fields λ continues to increase with the field but not in accordance with any definite law, and the curve showing its variation with the field exhibits inversion at B = about 6. T. H. P.

117. *Subsequent Magnetism of Iron.* V. **A. Bernini.** (N. Cimento, 8. Ser. 6. pp. 37–51, July, 1914.)—Using two samples of iron similar to those employed in his previous investigation [see preceding Abstract], the author has extended the latter to more intense fields, the maximum being one of 20 units. The results show that: (1) the values of the subsequent magnetisation and of the total induced magnetisation, as well as the ratio of the former to the latter, diminish as the specimen is subdivided along the lines of force of the field; (2) the ratio of the subsequent to the total magnetisation diminishes continuously with increase of the strength of field, and (3) the absolute value of the subsequent magnetisation at first increases to a maximum and then diminishes with increasing slowness and tends to vanish, as the field is increased. T. H. P.

118. *Thermomagnetic Properties of Iron and Steel.* **K. Honda** and **H. Takagi.** (Sci. Reports, Tôhoku Univ., Sendai, 2. 5. pp. 203–216, Feb., 1914.)—Employing the same arrangement as in the previous research [see Abstract No. 1892 (1914)], pure iron and a number of carbon steels were examined and their I-H curves derived. The results are stated as follows:—Between 20° and 240° there is, in all steels, a change of magnetisation which increases with increase of carbon. At the eutectic temperature of ferrite and cementite, there is a discontinuity in the magnetisation; this change increases with increase in the amount of the eutectic. The upper temperature limit of ferromagnetism in steel is approximately constant; ferromagnetism is therefore a property, not only of the *a*-state, but also of the γ-state for steels rich in carbon. The results are also well illustrated by numerous curves.

G. E. A.

119. *Further Experiments with Liquid Helium. Appearance of Incipient Paramagnetic Saturation.* **H. K. Onnes.** (Konink. Akad. Wetensch. Amsterdam, Proc. 17. pp. 283–286, Sept. 26, 1914. Communication No. 140*d* from Phys. Lab., Leiden.)—Lowering of the temperature seems to furnish a means by which paramagnetic saturation may be observed. Since, with the help of helium, temperatures may be attained which are as much as 150 times as low as the ordinary temperature, the result will be equivalent to raising the magnetic field 150-fold. Experiments have been made with crystallised gadolinium sulphate and the results obtained confirm Langevin's theory

qualitatively; before quantitative agreement can be tested, various corrections, such as that due to the demagnetising action of the paramagnetisation, remain to be investigated. The method of measurement consisted in determining the attraction in a non-homogeneous field, the gadolinium sulphate in the cryostat being cooled, first in liquid hydrogen under normal pressure, next in hydrogen under reduced pressure, then in helium boiling at ordinary pressure, and finally in helium under 4 mm. pressure, the apparatus and the fields being the same in each case. Curves have been constructed representing the observed attractive force as a function of the square of the field on the axis between the poles, this field being read as a function of the current from a calibration curve. The curve for 20·3° K. is virtually a straight line, whilst those for 14·7° K., 4·25° K., and 1·9° K. curve increasingly towards the square of the field axis, in correspondence with Langevin's theory. Within the limits of accuracy to be expected, the tangents of the angles of elevation of the tangents to the curves at the origin appear to be inversely proportional to the temperature, as required by Curie's law, and the deviations of the curves from the tangents, as expressed by the ratio between the ordinates of the two for a given abscissa, are strikingly similar to the corresponding deviations of Langevin's curve for the magnetisation as a function of the field. T. H. P.

120. *The Corbino Effect.* **E. P. Adams** and **A. K. Chapman.** (Phil. Mag. 28. pp. 692–702, Nov., 1914.)—The close relation between the Hall-effect and the Corbino-effect (which consists in the production of a circular current in a disc in which a radial current is flowing when a magnetic field at right angles to the plane of the disc is applied) is pointed out. The effect is measured by determining the induced current in a circular coil coaxial with the disc, on the radial current in the disc being reversed. The magnetic field remains constant, and its direction is parallel to the axis of disc and coil. A null method is employed and this is described. It is found that the sign of the Corbino-effect in various metals is always the same as that of the Hall-effect. In all metals except bismuth the magnitude of the Corbino-effect is proportional to the radial current and to the strength of magnetic field. Cu, Fe, Al, Bi, Sb, Pt, Au, Ag, Ni, Zn, Cd, Co, Sn, and Pb were all experimented upon, and a table of the relative values of the Corbino-effect is given. Also, on the assumption of the electron theory, the mean free time of an electron is calculated to be $2{\cdot}8 \times 10^{-14}$, and the mean free path $8{\cdot}1 \times 10^{-7}$ for copper. S. G. S.

121. *Thermo-electricity and Magnetostriction of Heusler Alloys.* **L. O. Grondahl.** (Phys. Rev. 4. Ser. 2. pp. 325–330, Oct., 1914.)—Previous work [see Abstract No. 398 (1912)] had shown that in some Heusler alloys the thermo-e.m.f. is affected by a magnetic field, and varies from specimen to specimen. The method employed for the measurement of the magnetostriction was that of Guthe and Austin, and the magnetostriction curves for fields up to 1600 gauss show no maximum and are always positive. Some of the curves showing the effect of the magnetic field on the thermo-e.m.f. pass through a max. negative value and then reverse. The magnetostriction decreases as the temperature rises, and disappears as the substance passes through the transformation-range, whilst the effect of the magnetic field on the thermo-e.m.f. does not disappear even at temperatures considerably above the transformation-range. Hence the two effects seem to be entirely independent of one another. The Kerr-effect was sought in these alloys, with a negative result. G. E. A.

122. *Experiments with Liquid Helium. Hall-effect.* **H. K. Onnes and K. Hof.** (Konink. Akad. Wetensch. Amsterdam, Proc. 17. pp. 520–527, Nov. 7, 1914. Communication No. 142*b* from the Phys. Lab., Leiden.)—Experiments were made with cadmium, graphite, gold, silver, bismuth, lead, tin, and nickel at hydrogen- and helium-temperatures on the Hall-effect and the change of resistance in a magnetic field. For the Hall-effect both the galvanometer deflection method and the compensation method were used. The following are the chief results for the Hall-effect at helium temperatures :

H (field).	Metal and Temp.	R (Hall-effect).
11,300 gauss	1. Sn. $T = 4{\cdot}25°$ K.	$+2{\cdot}6 \,.\, 10^{-5}$
	$T = 2{\cdot}8°$ K.	$+9{\cdot}8 \,.\, 10^{-5}$
300 „	2. Pb. $T = 4{\cdot}25°$ K.	$< 6 \,.\, 10^{-5}$
11,300 „		$+1{\cdot}8 \,.\, 10^{-4}$
11,300 „	3. Ag. $T = 4{\cdot}25°$ K.	$16 \,.\, 10^{-4}$
1300 „	4. Ni. $T = 4{\cdot}25°$ K.	$< 5 \,.\, 10^{-5}$
11,300 „		$< 1 \,.\, 10^{-5}$
1000 „	5. Bi. $T = 4{\cdot}25°$ K.	86·3
11,300 „		85·7

Curves are also given showing the change of resistance in the magnetic field.

J. J. S.

123. *The Local Magnetic Constant and its Variations.* **L. A. Bauer.** (Terrestrial Magnetism, 19. pp. 113–125, Sept., 1914.)—Good progress has been made by various investigators in establishing the relationship between fluctuations of the earth's magnetism and those of the sun's activity during the sun-spot cycle. The magnetic quantity most frequently used for this purpose has been the range of the diurnal variation—generally of the magnetic declination. In connection with a preliminary examination of this relationship made five years ago in response to an inquiry received from Hale, of the Mount Wilson Solar Observatory, the author had occasion to employ various other magnetic quantities. One of these was what is here termed the "local magnetic constant," which, under certain assumptions, is proportional to the magnetic moment of the earth, or to the intensity of magnetisation. The desire was to use for the examination a quantity yielding results which might be more readily susceptible of a physical interpretation than those generally obtained. In this paper this constant is designated by G, and is the same as the *c* used in previous papers [Abstract No. 1449 (1912)].

Supposing that the earth's magnetic field arose from a uniform magnetic system wholly enclosed within the surface, then the author shows that—

$$G = \sqrt{H^2 + \tfrac{1}{4}Z^2}, \quad dG = \frac{H}{G}dH + \tfrac{1}{4}\frac{Z}{G}dZ,$$

where H is the horizontal intensity and Z is derived as follows : At any point outside the surface let the total magnetic intensity be resolved into three rectangular co-ordinates, one along a meridian position towards the north, one along a parallel of latitude position towards the east, then Z is that along the vertical position towards the nadir.

By means of this quantity G, which would be constant over the whole earth were the latter uniformly magnetised, local and regional irregularities can readily and suitably be expressed ; the reasons why the letter G has been finally adopted to designate it being stated. The geographical variation of G succinctly exhibits the complexity of the earth's magnetic field. Instead of being constant over the earth as it should be in the case of a uniform internal magnetic field, it may vary 33 % from its average value (about 0·324 c.g.s.). A change in G may be caused by an external system, or from a combination, as is usually the case, of an external and an internal system.

The author examines the records for various American magnetic observations for 1906–1909 with a view to studying the relationship between solar activity and terrestrial magnetism. The magnetic data plotted are the average results for a calendar month. The general preliminary results are as follows:—There is a fairly good general correspondence of the solar activity curve with all the magnetic curves, better for the sun-spot curves than for the calcium flocculi. The diurnal ranges in the magnetic elements, as well as the changes in the absolute elements themselves, and likewise in the local magnetic constant, all appear related in some manner to solar activity. But the general agreement does not hold *quantitatively*. The same change in solar activity is not always followed by a similar magnetic increment or decrement. The deduction of most interest, being a novel one, is derived from a comparison of the solar curves with the changes shown in the local magnetic constant. An increase in solar activity is accompanied by a decrease in the local magnetic constant as shown in the curves that have been plotted. This is shown consistently by observatories as remote from one another as is Honolulu from Cheltenham (Maryland).

The question next arises whether any changes in the earth's magnetism follow the same course as that of the solar constant of radiation. In order to eliminate, as far as possible, the effects attributable perhaps to phenomena associated with sun-spots, the years chosen were 1911 and 1912, the latter being the year of sun-spot minimum according to Wolfer's numbers.

The values of the solar-constant showed a range of about 10 % between highest and lowest values during 1911 and 1912, hence the max. change in the magnetic constant, G, if attributable to the change in the solar-constant would be about 1/30 % of its value. The result found, if correct, is extremely interesting not only because of its magnitude, but especially because increased solar radiation would apparently correspond to diminished value of the magnetic constant, *i.e.* the effect would be similar to that caused by heating a magnet, though it is not to be inferred at present that the effect is of this nature. The apparent change in the local magnetic constant of about 1/30 % of its value is about $0{\cdot}00010 \times 10^{-6}$ c.g.s. The effect appears to be most pronounced for the observatories in the sunlit portion of the globe, and seems to be reversed for the observatories in the night portion, judging from the place where the corresponding solar observations are made. This is being looked into further. Anticipating that there might be such an effect, the first tests were applied almost wholly for observatories which were in the daylight zone as judged from the solar stations, so that it did not matter materially whether absolute time or local time was used.

Several of the years seem to show a seasonal drift, or a running down, in the solar-constant values. The magnetic constant, after a severe magnetic storm or after a period of continued magnetic agitation, shows a running down similar to the apparent running down of the solar-constant at times after a period of prolonged solar agitation.

There remain for consideration those particular disturbances which, sudden in appearance, do not occur simultaneously over the globe, but instead, each time the disturbance occurs, only the observatories in the daylight zone record it. They are of short duration—½ or ¾ hour—and occur at times when the magnetic conditions are otherwise calm. On the average for the various observatories over the globe the change in G for the recorded disturbances was about 10×10^{-6} c.g.s. If the solar radiation really varies in the remarkable manner indicated by Abbot, it is not surprising that magnetic observatories should continually be recording magnetic perturbations even on apparently undisturbed days.

From the data available from 1840 to 1885 and investigated by the author in 1903, the earth's magnetic moment was found to have apparently diminished at the average annual rate of 1/2580 part, a value confirmed by later observations taken during the period 1890–1900. The author adds a table to show for certain regions in the N. and S. hemisphere, the average annual change of G, in gammas, between 1900 and 1910. This change is for most regions negative, but in the southern and eastern portions of Asia, positive. Within a few years the new magnetic charts of the Carnegie Institution of Washington will be available, and it will then doubtless be possible to settle definitely the interesting question as to whether the earth, like every other magnet, is steadily losing its magnetic energy.

The table discloses the fact that the most remarkable change is occurring at present in the eastern portion of the Indian Ocean, as has been already indicated by the observations made on the *Carnegie*. In this region the annual diminution in G approaches 0·001 c.g.s., or about 1/800 part, or about the same as that caused by a moderate magnetic storm. E. O. W.

124. *Influence of Sun on Terrestrial Magnetism.* **R. S. Capon.** (Observatory, No. 478. pp. 341–344, Sept., 1914.)—Notes are given on the theory and experimental investigations of Birkeland and Störmer, regarding the terrestrial magnetic phenomena as due to kathodic radiation from the sun, modified by their encountering the ring of electrified particles in the equatorial plane of the earth, and circling round it. To measure the deviability, elaborate observations of details of the auroral streamers were made from two stations 4280 m. apart. The chief difficulty in accepting this theory is that as yet no account has been taken of the electric interaction between the particles.

C. P. B.

RADIOGRAPHY AND ELECTROPHYSIOLOGY.

125. *Simple Manner of obtaining an Idea of Relief in Radioscopy.* **F. Garrigou.** (Comptes Rendus, 159. pp. 657–659, Nov. 9, 1914.)—One of the chief difficulties attending the practical application of radioscopy to surgery is ascertaining the exact depth at which some foreign body is embedded in the tissues under examination. A very simple piece of apparatus is here described by means of which an examination of a radiograph will give to a surgeon the desired information. A. E. G.

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CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

126. *Salts coloured by Kathode Rays.* **E. Goldstein.** (Engineering, 98. p. 610, Nov. 20, 1914. Paper read before the British Assoc., Australia, 1914. Nature, 94. pp. 494–497, Dec. 31, 1914.)—It has long been known that salts bombarded by kathode rays become discoloured. This was ascribed by Giesel to partial decomposition of the salt, resulting in the reduction of some of the metal. But the present author found this discolouration may occur in the absence of all metals and in inorganic compounds containing chlorine, bromine, etc. It is here suggested that there is no real reduction, but that the compounds are *distended, i.e.* that the bands between them are loosened. In this distended condition, common to all the elements, matter has a high absorptive power for light. The colours are producible by a very short exposure to kathode or β-rays or to ultra-violet light, to which last agency the real effect is here ascribed. A connection appears to exist between these phenomena and the therapeutic effect of radium and mesothorium in the treatment of skin and other diseases. E. H. B.

127. *High-frequency Spectra and the Periodic Table.* **W. M. Hicks.** (Phil. Mag. 28. pp. 139–142, July, 1914.)—The validity of Moseley's law governing high-frequency spectra is of decisive import in questions affecting the periodic table, and it leaves only 12 spaces to be filled between Ce and Yb, while the ordinarily accepted view gives 16. A possible explanation would be a splitting of the L series into two at some element between Nd and Yb, with a new formula depending on $(N - 8)^2$ in place of $(N - 7)^2$; and it may be noted that there appears to be some disturbance in Moseley's curve in this region. The author, however, prefers to regard Moseley's rule as absolute, and supports his preference by evidence cited in a recent paper by J. R. Rydberg [Lunds Univ. Arsskrift, N.F. Afd. 2. 9. No. 18, and Abstract No. 2012 (1914)], from which a table is reproduced. G. W. DE T.

128. *Terbium.* **C. James** and **D. W. Bissel.** (Amer. Chem. Soc., Journ. 36. pp. 2060–2066, Oct., 1914.)—The authors first survey all previous investigations relating to this element, and analyse the practicability of the various methods of separation put forward. As starting material they use a gadolinium oxide containing, besides terbium, some dysprosium and holmium oxides with traces of yttria and erbia. The mixed oxides are converted into bromates and carefully fractionated. In the least soluble fractions a faint absorption band develops in the blue, due to europium whose bromate is the least soluble of all the rare-earth bromates. Next in order of increasing solubility come gadolinium, neodymium, terbium, dysprosium, holmium, yttrium, erbium, thulium, ytterbium, lutecium, celtium, and scandium. Gadolinium is obtained from the bromate as an almost white oxide. With increase of solubility of the bromates the oxides become darker up to a maximum, after which they become paler. From the most soluble fractions a buff-coloured oxide is obtained. The fractions giving the darkest coloured oxides show only one absorption band, that of terbium. The pure nitrate of terbium gives a single band in the blue round about $\lambda 4875$ Å.U.

The authors conclude from their investigations that only one terbium exists. C. S. G.

129. *Metastability of the Metals in Consequence of Allotropy and its Significance for Chemistry, Physics, and Technics.* II. **E. Cohen.** (Konink. Akad. Wetensch. Amsterdam, Proc. 17. pp. 200–208, Sept. 26, 1914.)—The early literature on the specific heats of the metals contains a number of data showing that these magnitudes depend on the previous thermal history of the metals [see Abstract No. 987 (1914)]. Thus, Le Verrier [Comptes Rendus, 114. p. 907, 1892] states that, as a rule, the mean specific heat of Cu, Zn, Pb, Al, and Ag remains constant up to 200–300°, beyond which it changes abruptly, and similar behaviour was observed by Pionchon [Comptes Rendus, 102. pp. 675 and 1454; 103. p. 1122, 1886] with Fe, Ni, and Co. In the neighbourhood of these breaks the condition of the metals is a function, not only of the temperature but also of the thermal history. If a piece of metal is repeatedly cooled or heated, different values are found for the total heat; and starting from a low temperature and returning to it after having traversed the break in the total heat curve, a closed and not a single curve is obtained. This result is in complete harmony with the dilatometric and e.m.f. measurements carried out by the author, in conjunction with Helderman and Moesweld, on Cu, Cd, Zn, and Bi. The transition temperatures deducible from Le Verrier's observations will generally be too high, owing to the retardation of the molecular changes. According to Le Verrier, Al shows an absorption of 10 cals. at 535°, and Dittenberger proved ten years later that this metal is capable of existing in more than one allotropic modification, the transition temperature lying between 500° and 600°; these observations are of importance with reference to the disintegration often occuring in Al objects at the ordinary temperature. That others have not observed Le Verrier's phenomena may be explained by the fact that they did not heat their preparations repeatedly to high temperatures. The author's dilatometric investigations showed that the transition-point may be exceeded by several hundred of degrees without any effect, but if the metal is repeatedly cooled and heated the transition is "set going." T. H. P.

130. *Dilute Solutions of Aluminium in Gold.* **C. T. Heycock** and **F. H. Neville.** (Roy. Soc., Phil. Trans. 214. pp. 267–276, Sept. 23, 1914. Roy. Soc., Proc. Ser. A. 90. pp. 560–562, Aug. 1, 1914. Abstract.)—Gives an account of the determination of the complete equilibrium diagram of aluminium and gold up to a content of 5 % of Al. Results of cooling-curve determinations and microscopic examinations of ingots after annealing and after chilling from certain temperatures are given and illustrated. In the case of the alloy containing 3·32 % Al, heat evolution commences at 543° and continues for some time, being due to the solidification of solid solution β. The next heat evolution occurs at 450°, and is probably due to the crystallisation of the compound Al_3Au_8. A well-marked flat occurs in the curve at 424°, indicating the formation of eutectoid. On further cooling, a recalescence begins at 388°, and almost instantly raises the temperature to 428°. A similar recalescence can be detected in all alloys from 10 to 27 atomic per cent. of aluminium. Both the initial temperature and the rise in temperature are very variable, the latter being sometimes as much as 70 deg. This is essentially an explosive phenomenon; that is, a change takes place below the temperature at which it ought to occur and the temperature to which the recalescence carries the ingot may not reach that at which the new system would be in equilibrium with the old one. In heating-curves the first marked absorption of heat begins at 520°, and this probably indicates the equilibrium temperature of the recalescence reaction. A marked change in structure occurs at the recalescence, for ingots chilled above 420° show closely-fitting polygons of solid solution, whilst those chilled at 400° show a structure filled with polygons, bars and sprays of a second substance which is probably richer in Al. Recalesced ingots lose all trace of the recalescence pattern when heated above 520°. Results are given of experiments on forcing the recalescence by touching the ingot with a cold steel wire. C. O. B.

131. *Internal Strains in Cold-wrought Metals and some Troubles caused thereby.* **E. Heyn.** (Inst. of Metals, Journ. 12. pp. 3–37, May Lecture, 1914. Mech. Eng. 33. pp. 500–503, May 29 ; 527–529, June 5, and pp. 548–550, June 12, 1914.)—Internal strains are brought about by portions of a solid being hindered from assuming the dimensions they would assume in the absence of stress. The method devised at the Materialprüfungsamt for ascertaining whether a bar is self-strained or not, and for determining the magnitude of the internal strains, consists in turning off successive layers from a round bar and measuring the distance between two marks on the cylindrical surface after the removal of each layer. Changes in length indicate the existence of internal strains, the magnitude of which can be calculated from a knowledge of the elastic modulus of the material, the sectional area of the removed layer, and the alteration of the distance between the marks. Elastic deformation is an essential feature of the setting-up of internal strains. They are therefore more pronounced in materials which have been cold-worked than in hot-worked materials. Cold-drawing results in the production of tension strains in the outer layers and compression strains in the core, while cold-rolling and hammering tend to produce compression strains in the outer layers and tension strains in the core. Experiments were made on a 25 % nickel steel which had been reduced 20 % in section by cold-drawing. The results showed that the max. tension stress existing in the outer layers amounted to about 50,000 lbs. per sq. in., while the max. compression stress in the core amounted to about 54,000 lbs. per sq. in. After annealing at 850° C. the strains were removed. Liability to cracking may often be revealed by dipping the piece in mercury or a solution of mercury nitrate. Experiments appear to indicate that some change in the distribution of stress takes place in the course of time, but the evidence on this point is not quite conclusive. Reheating gradually removes the internal strains, the effect becoming apparent much below the temperature limit at which the effect of cold-working is completely removed. "Season cracking" is undoubtedly due to internal strains, and may be brought about by external forces bringing up the internal stresses until the ultimate strength of the material is exceeded in part of the mass. Unequal heating, local injury, and local corrosion, or pitting, may also have the same effect. It is shown by calculation that the limit of proportionality is highly dependent on the magnitude and distribution of internal strains. It is even possible that the elastic limit may appear to be depressed by cold-work, instead of raised as is generally the case. F. C. A. H. L.

132. *Manganese Steel and the Allotropic Theory.* **A. Sauveur.** (Amer. Inst. Mining Engin., Bull. No. 93. pp. 2439–2449, Sept., 1914.)—The author disagrees with the conclusions of Hadfield and Hopkinson to the effect that the behaviour of manganese steel on heat-treatment cannot be explained satisfactorily by the allotropic theory. Relatively rapid cooling is necessary to retain Mn steel in the pure austenitic condition. The metal is then non-magnetic, has a low elastic limit and hardness, while its tenacity and

ductility are high. On very slow cooling the metal becomes slightly magnetic, and its hardness is increased. This is quite satisfactorily explained by the assumption that slow cooling increases the hardness by producing a small amount of β iron and renders the material ferromagnetic by converting some of the γ iron into the α variety. The fact that manganese steel containing 12 % of Mn does not become magnetic on cooling in liquid air, while nickel steel does regain its magnetic properties under such treatment, is satisfactorily explained by the fact that the temperature-concentration curve of the loss of magnetism is steeper in the case of Mn, than in the case of Ni steels. The results of heat-treatment experiments on a steel containing 1·25 % of carbon and 12·5 % of Mn show that this type of steel may be obtained in three distinct modifications: (1) as a pure austenite steel containing a considerable amount of free carbide, produced by slow cooling from above 700° C.; (2) an austenite steel produced by rapid cooling from high temperatures; and (3) a martensitic steel produced by reheating the pure austenitic steel at temperatures between 500° and 700° C. In the first state the metal is weak, non-magnetic, and lacks ductility; in the second state it is non magnetic, but has a high tenacity and ductility; while in the third state it is ferromagnetic owing to the presence of some α iron, and its hardness is increased owing to the presence of a certain amount of β iron. F. C. A. H. L.

133. *Growth of Metallic Eutectics.* **F. E. E. Lamplough** and **J. T. Scott.** (Roy. Soc., Proc. Ser. A. 90. pp. 600–604, Sept. 7, 1914.)—Experiments made with a view to determining if the formation of haloes of the secondary constituent surrounding the primary crystals in various alloys is always accompanied by appreciable undercooling, and if the formation of these haloes is prevented by inoculation with the second constituent, showed that neither supercooling nor inoculation had any effect on the formation of the envelopes. Quenching the alloys during the solidification period of the eutectic showed in the case of the cadmium-tin system that the eutectic growth did not originate at the primary Cd crystals, and that the halo was only present round those primary crystals which had become enveloped by the growing eutectic. Other cases proved that the halo was produced when the eutectic approached the primary crystal, the further solidification of the eutectic at this point consisting of the deposition of a layer of the primary substance on the surface of the primary crystals, the other constituent having formed an envelope around the primary crystal. Pursuit of this mode of research showed that eutectics can be divided into two classes: (1) those of spherical radiating growth, and (2) those having well-defined crystal contours showing in section a herring-bone structure. To the first class belong the eutectics of Sn-Pb, Sn-Cd, Zn-Cd, Ag-Cu, Zn-Al, while the eutectics of Bi-Pb, Bi-Sn, and many eutectics of metals with intermetallic compounds belong to the second class. Envelopes have only been observed in conjunction with eutectics of Class 1. F. C. A. H. L.

134. *Effect of Re-melting on Copper.* **F. O. Clements.** (Mech. Eng. 34. p. 293, Oct. 2, 1914. Paper read before the Amer. Inst. of Metals. Metallurgical and Chem. Engin. 12. p. 644, Oct., 1914. Abstract.)—Gives the results of a series of tests showing the effect on the physical and chemical properties of copper of re-melting four times. In the average number of alternate bends before fracture the virgin metal gave 1515, which was reduced to 334 after the fourth melt. During the same melts the sulphur-contents were found to increase from 0·03 % to 0·11 %. Experiments were

afterwards made on the restoration of the injured copper by the addition of boron suboxide, 2 oz. being added to 16 lbs. of the copper. This treated metal gave an average of 2007 alternate bends, showing the value of this addition. C. O. B.

135. *The Theory of Colloid Chemistry.* **W. D. Bancroft.** (Journ. Phys. Chem. 18. pp. 549–558, Oct., 1914. Paper read before the Amer. Chem. Soc., Montreal.)—The author develops a working theory of colloid chemistry on the basis of the four following postulates: (1) Colloid chemistry differs from ordinary chemistry only through the variations resulting from the increasing dispersity of one or more phases. (2) Selective adsorption takes place at surfaces. (3) Sufficiently finely divided particles, which are prevented from coalescing, will be kept suspended in a medium by the Brownian movements. (4) Under fixed conditions of peptonisation we get an approximately definite limiting concentration corresponding to a saturated solution in the case of a true solution. T. M. L.

136. *Valency and Molecular Structure.* **W. C. Arsem.** (Amer. Chem. Soc., Journ. 36. pp. 1655–1675, Aug., 1914.)—The "bond" is regarded as an oscillating valence-electron. Valency is then the property which an atom possesses of sharing electrons with other atoms in such a way that the atoms so united form a stable neutral system, in which the valence-electrons oscillate periodically between the atoms which they unite. Valency is, therefore, a purely mechanical result of the dynamic relations between molecules and the atoms of which they are composed. The valency of an atom in a state of combination with other atoms is simply a numerical quantity, but the valency of a radical or an ion may be positive or negative. T. M. L.

137. *Studies in Conductivity.* II. *Conductivity of Formates and of Hydrogen Chloride in Formic Acid. Agreement of Strong Electrolytes with the Mass Law.* **H. I. Schlesinger** and **A. W. Martin.** (Amer. Chem. Soc., Journ. 36. pp. 1589–1620, Aug., 1914.)—The highly ionised solutions of sodium, phenyl ammonium, potassium and ammonium formates in (anhydrous) formic acid obey the law of mass-action up to concentrations of from 0·3 to 0·6 molar, if the degree of ionisation is calculated from conductivities to which no correction for viscosity is applied. The ionisation constants of the four salts are: 0·816, 0·814, 1·02, and 1·23. The same thing is true of solutions of hydrogen chloride, the ionisation constant of which is only 0·04. Above the concentrations mentioned, the formates deviate from the mass law in the sense that the degree of ionisation is less than it should be. The data for sodium formate, up to the highest concentrations measured, show fair agreement with the equation $\alpha^2c/[(1-\alpha)(1-v_mc^{\alpha})]=K$, which is derived on the assumption that the deviation in the concentrated solutions is due to the reduction of the free space by the volume occupied by the solute itself.

Ammonium formate, with a constant of 1·23, begins to deviate above 0·55 molar; potassium formate, whose constant is 1·02, above 0·45 molar; and sodium and phenyl ammonium formates, whose constants are respectively 0·816 and 0·814, both begin to deviate from the law at about 0·3 molar. It seems, therefore, that the greater the value of the ionisation constant, the higher the point at which deviation begins. When the conductivities are corrected for viscosity the agreement with the mass law disappears. It appears, therefore, that the uncorrected conductivities are the ones to be used here for calculating the degree of ionisation.

In formic acid the mobilities of the ions do not differ as much as they do in aqueous solutions. It is therefore not permissible to set up a general equation expressing relationship between the conductivities at infinite dilution in various solvents and the viscosities alone. T. M. L.

138. *New Cell Arrangement for Direct Determination of "Free Energy."* **R. Beutner.** (Amer. Electrochem. Soc., Trans. 25. pp. 441–465, 1914. From the German.)—The e.m.f. of a reversible galvanic cell is proportional to the free energy of the reaction which takes place in the cell. This important quantity is difficult to measure because most cells contain p.d.'s at the junction of miscible electrolytes (so-called diffusion potentials), which depend in a complicated way on ionic mobilities, and must be subtracted from the total e.m.f. in order to get a quantity related to the free energy. The author has therefore devised a number of cells built up from immiscible electrolytes (mostly solid salts), and arranged in such a manner that equilibrium exists at all junctions of two phases, and no changes in concentration can arise within any one phase. Typical examples are—

Ag | AgCl (solid) | Ag_2SO_4 (solid) Ag
Ag | AgCl (solid) | $PbCl_2$ (solid) | Pb
Cu | $CuSO_4$ + $ZnSO_4$ (saturated solution) | $ZnSO_4$ (solid) | Zn.

T. M. L.

139. *Potential of Silver in Non-aqueous Solutions of Silver Nitrate.* **V. L. Gibbons** and **F. H. Getman.** (Amer. Chem. Soc., Journ. 36. pp. 1630–1655, Aug., 1914.)—Measurements of conductivity are given for solutions of silver nitrate in alcohol, methyl alcohol, acetone, aniline, and pyridine from 0·1 to 0·0001N. The curve for aniline rises to a remarkable maximum about $v = 1$ and then tends towards another maximum at extreme dilution. This abnormality tends to disappear as the dielectric constant of the solvent rises from aniline, 6·85, to water, 81·1. The experimental data seem to prove that the abnormalities in non-aqueous solutions are due to the combination of the solvent and the solute to form complex compounds which dissociate more or less gradually.

The transport numbers of silver nitrate in ethyl alcohol, methyl alcohol, and pyridine were determined experimentally and measurements of e.m.f. were made for concentration cells, in an apparatus which is free from defects due to capillarity and constant communication of the two liquids. The electrode-potential of silver in the different solvents, referred to the hydrogen electrode as here, was calculated to be as follows :—

Ethyl alcohol	+ 0·1004	+ 0·7331	+ 0·00217	+ 0·8314
Methyl alcohol......	+ 0·0967	+ 0·7331	— 0·00005	+ 0·8298
Acetone	+ 0·1712	+ 0·7331	+ 0·00202	+ 0·9022
Aniline	— 0·2559	+ 0·7331	—	—
Pyridine	— 0·3618	+ 0·7331	+ 0·00017	+ 0·3711

T. M. L.

140. *Concentration Cells in Ionised Gases.* **W. H. Jenkinson.** (Phil. Mag. 28. pp. 685–692, Nov., 1914.)—On the assumption that the passage of electricity from metal to air is a phenomenon which may be treated as reversible in a thermodynamic scheme, the latter is exactly the same as that originally elaborated by Nernst in his theory of electrolytic solution pressure for the p.d. between a metal and an electrolyte. The p.d.

between metal and air will, therefore, be given by the formula, $V = RT\,(2r-1)\log(P/p)/\epsilon$, where p is the ionic pressure of either kind of electricity in air and P is the equivalent of "solution pressure" for the metal the ions of which are transferred. If p is altered by the operation of an ionising agent, V should undergo a corresponding change and, if P is not affected by the agent, two wires in regions of air ionised to different extents, p_0 and p_1, would form a concentration cell having the e.m.f., $RT\,(2r-1)\log(p_0/p_1)/\epsilon$. Such a cell was made by arranging two insulated copper wires, connected with a Dolezalek electrometer, in a thick leaden box fitted with a window of thin Al-foil, through which the ionising rays were admitted. X-rays were at first used, but, owing to the impossibility of keeping the tube constant for the long time necessary, the experiments were continued with radium. In all cases a deflection was gradually set up which ultimately assumed a steady value and became reversed in sign when the thick aluminium shield employed was changed from one electrode to the other; the unshielded electrode was always found to be positive to the shielded one. The positive ion must, therefore, be the controlling agent in the production of the p.d. and the results also suggest that the negative ions take no part in the transference of electricity across the surface. This conclusion is in agreement with the known facts of contact electricity, which indicate that a metal is ordinarily at a lower potential than the air, while the discharge of electricity from heated metals also takes place by the emission of positive ions unless very high temperatures are reached. As regards the meaning of P, the presence of an occluded layer of gas in a metal surface seems to be an essential feature in the production of the p.d. between metal and air and P apparently represents the ionic pressure in this occluded layer, the formation of which would be thermodynamically reversible. T. H. P.

141. *Measurement of Oxidation Potentials at Mercury Electrodes.* I. *The Stannic-Stannous Potential.* **G. S. Forbes** and **E. P. Bartlett.** (Amer. Chem. Soc., Journ. 36. pp. 2030–2040, Oct., 1914.)—The values obtained by previous observers for the stannic-stannous potential exhibit marked discordance. The author's work shows that mercury is preferable to Pt in the measurement of oxidising potentials of low intensity, the results being more rapidly obtained and less dependent on irregularities in surface energy of the electrode and on the presence of traces of oxygen. The potentials of mixtures of stannic and stannous chlorides containing 0·25 gm.-atom of Sn per litre in hydrochloric acid of three different concentrations were measured at Hg electrodes at 25°, the probable error being about 2 millivolts. The potential is nearly independent of the total concentration of the tin, but is rendered very slightly more electronegative by halving this concentration, other conditions being constant. Extrapolation to zero concentration of acid gives results which should be affected but little by uncertainties due to hydrolysis, and to the single potential of the boundary between the cell liquid and the indifferent electrolyte. For concentrations of hydrochloric acid up to 2 mols. per litre, the potentials are expressed accurately by the formula, $\pi = 0{\cdot}426 + 0{\cdot}030\log(\mathrm{Sn^{IV}}/\mathrm{Sn^{II}}) - 0{\cdot}11 \times$ concentration of HCl, provided sufficient acid is added to prevent hydrolysis. T. H. P.

142. *Passivity of Metals.* **H. G. Byers** and **S. C. Langdon.** (Amer. Chem. Soc., Journ. 36. pp. 2004–2011, Oct., 1914.)—The term passivity is applied to the condition of an element showing abnormal electrochemical relations, and a chemical inactivity not corresponding with its ordinary behaviour, and not in accord with its position in the electromotive series of the elements [see Abstract No. 2065 (1908)]. Experiments made with iron as anode and dilute sulphuric or nitric acid as electrolyte show that the passive state is conditioned, not only by the six factors previously enumerated [see Abstract No. 1564 (1913)], but also by the concentration of the dissolved oxygen about the anode, and that this appears to be the determining factor. When all these factors are taken into account, constant results are obtainable with respect to the time required to render iron passive with a given current in sulphuric acid, and in nitric acid a critical current density is determinable. The most satisfactory explanation of passivity is furnished by Faraday's statement that the state is one of a very delicate equilibrium between oxygen and iron. It appears, indeed, that oxygen is occluded by the iron and the results of an incomplete investigation indicate that increase of oxygen pressure does not, at least at small pressures, increase the anodic potential shown by iron anodes. The appearance of the passive condition on metals simply immersed in electrolytes is accounted for by the presence of pure oxygen in the solutions. When not associated with a visible film, passivity is regarded as due to the insufficiency of the rate of ionisation of certain metals to carry currents exceeding certain densities. When such current density is exceeded, oxygen electrodes, consisting of occluded oxygen, are formed in oxygenated electrolytes. Non-anodic passivity is likewise due to occlusion of oxygen and consequent protection of the metal from attack. T. H. P.

143. *Electrolytic Strontium.* **B. Neumann** and **E. Bergve.** (Zeitschr. Elektrochem. 20. pp. 187–188, March 15, 1914. Rev. Électrique, 22. p. 238, Sept. 18, 1914. Abstract.)—The melting-point of strontium chloride is 848°, that of eutectic with 15·9 % of KCl is 628°, while strontium metal melts at 600°. The electrolysis of fused mixtures of the two salts gives strontium free of potassium with a yield of over 80 %, whilst the direct electrolysis of fused $SrCl_2$ (Borchers and Stockem) has a poor yield. The authors proceed, after Rathenau and Suter, with a vertical contact electrode, an iron rod which is slowly raised, and obtain with currents of 20 to 50 amps./cm.² strontium rods from 1 to 2 cm. in thickness up to 10 cm. in length; the salts are fused by the current heat. A mixture of $SrCl_2$ and KCl had already been used by Trautz in 1911, but merely for the suppression of metallic fog in the bath; he operated at bright red heat.

The paper is a preliminary communication. H. B.

144. *Technical Preparation of Baryta.* IV. *Electrolysis of Aqueous Solutions of Barium Sulphide.* **L. Marino** and **U. Gigli.** (Gazzetta Chim. Ital. 43. 2. pp. 1–25, July 15, 1913.)—An examination of the process of Brochet and Ranson (1903) for the preparation of baryta in diaphragm cells from warm solutions of the barium sulphide. The sulphide concentration of the electrolyte should be about 20 %, and the electrolysis at 70 to 80° C. should not be pushed beyond two-thirds of the time theoretically required for the complete decomposition. Under suitable conditions the yield closely approaches the theoretical. Of the kathodes and anodes tried, Fe, Cu, Pb, Ni, also anodes of C, the copper electrodes answered best. Barium hydroxide is formed at the anode by the interaction of hydroxyl ion and barium sulphide; the current density at the anode should range between 1 and 3 amps./dm.². H. B.

145. *Electrochemistry of the Chromium Group.* I. *Tungsten and Uranium.* **A. Fischer.** (Zeitschr. Anorg. Chem. 81. pp. 170–208, 1913.)—The author

and A. Roderburg prepare rods of tungsten by the method of H. v. Wartenberg [Abstract No. 2065 (1907)] by producing the arc in a vacuum bulb between tungsten electrodes using an auxiliary tungsten electrode to start the arc. The rods are immersed in alcoholic solution of tungsten hexachloride, and potential measurements are made against a calomel electrode, an alcoholic solution of lithium chloride being interposed. The tungsten does not turn passive; its potential is at least 0·609 volt, but its position, between Sb and Hg, could not exactly be determined. As the Wartenberg method does not, according to the author and E. K. Rideal, yield a uranium metal of sufficient conductivity for producing fused rods, the uranium oxide mixed with carbon was reduced in a vacuum furnace; the uranium was hence not free from carbon, and its potential in alcoholic solution of uranium hexachloride could not definitely be determined either; it lies between copper and hydrogen. The same investigators also tried to prepare the two metals by electrolysis of solutions in absolute alcohol. Tungsten hexachloride gave green crystals of a compound $C_6H_{16}O_3Cl_3W$, possibly $WOCl_3(OEt)_3$. Uranium did not yield a similar compound; but from uranium acetate a hydrate was obtained, and various acid and alkaline solutions gave on electrolysis the same uranium oxide, not metal. H. B.

146. *Electrolysis of Fused Mixtures of Sodium and Potassium Salts.* **B. Neumann** and **E. Bergve.** (Zeitschr. Elektrochem. 20. pp. 271–275, May 1, 1914. Rev. Électrique, 22. pp. 238–239, Sept. 18, 1914. Abstract.)—Castner having already observed that the electrolytic reduction of sodium from the fused hydroxide should be conducted at low temperature, the authors investigate the lowering of the melting-point of NaOH by the addition of Na and K salts. NaOH melts at 290°, KOH at 345°; when KOH is added to NaOH, the melting-point is first lowered and then raised, the minimum being 167° for (41·6 % NaOH + 58·7 KOH); mixtures of sodium hydrate and sodium carbonate have their minimum melting-point of 280° for ($83\ NaOH + 17\ Na_2CO_3$); mixtures of sodium hydroxide with the two carbonates have the minimum at 263° for [$79{\cdot}3\ NaOH + 20{\cdot}7\ (Na_2CO_3 + K_2CO_3)$]; the lowering of the freezing-point was in all cases in accordance with Raoult's law. The electrolysis of these mixtures, however, always yields mixtures of the two metals, never sodium alone. The more potassium the bath contains, the more of this metal is deposited; a mixture of (60 % NaOH + 40 % KOH) yields the two metals in these proportions; increase of the current density also increases the yield of potassium. Similar rules hold for mixtures with carbonates. The electrolysis is performed in a nickel crucible with anode ring and kathode rod, both of nickel, by currents at 8·9 volts and 1 amp./cm.^{2} at the anode. H. B.

147. *Electrolysis by Superposed Alternating and Continuous Currents.* **O. Reitlinger.** (Zeitschr. Elektrochem. 20. pp. 261–269, May 1, 1914. Rev. Électrique, 22. p. 239, Sept. 18, 1914. Abstract.)—Since the superposition of alternating on continuous currents lowers the overvoltage, the author investigates whether by these means the yield of the intermediate products (at the expense of the final products) could be increased. Dony Hénault had shown in 1900 already that the electrolysis of alcohols yields aldehydes when the anode potential is kept low, and acids when high. This is confirmed for ethyl and propyl alcohols. The electrolysis of sulphuric acid by superposed currents gives ozone, not persulphuric acid; a pulsating negative current has the same effect as alternating current. With alternating currents the

effect becomes weaker as the frequency rises, owing to the stronger phase-displacements by the capacity of the electrode. The electrolytic oxidation by superposed current of ammonia dissolved in sodium hydrate with copper as catalyst and lead peroxide anodes, gave nitrous acid, not nitric acid; the oxidation of toluene in sulphuric acid, giving benzaldehyde, and benzoic acid.
H. B.

148. *Alternating-current Electrolysis.* **J. C. Ghosh.** (Amer. Chem. Soc., Journ. 36. pp. 2333–2346, Nov., 1914.)—The author has measured the potential differences between an electrode and an electrolyte, (*a*) before the passage of an alternating current, (*b*) during, or just after the passage of the same, in order to see if there were any indications of chemical action taking place at the electrode surface [see Abstracts Nos. 1973, 2306 (1905)]. The potentials were measured against a decinormal calomel electrode, and the frequency of the alternating current was about 30,000 per min.

There is no variation in the electrode potential on the passage of an alternating current through a cell consisting of two electrodes of the same metal dipping into a solution of a salt of that metal. With polished Pt electrodes dipping into various solutions there is a change in potential. For example, acids may be divided into two groups according to their behaviour; the first group consists of acids which do not contain an HO-group, the potential diminishing on the passage of the alternating current; in the second group of acids, which contain either the Cl- or the HO-group, the opposite is the case. Salts which act as oxidising agents give an increase of potential, and those which act as reducing agents a decrease of potential on passage of the alternating current. In the case of salts such as KCl, NaCl, etc., the potential generally increases. These variations indicate that on a polished Pt surface, even for such short intervals of time as 1/60000 min., the chemical process at the electrode is not a reversible one, the ion having had time to part with its charge and form other, more stable bodies. Variations were also observed when mercury electrodes were substituted for Pt, but in many cases the nature of the variation was quite unlike that with Pt. With electrodes of platinum black the variations practically disappear. The variations, under the influence of alternating currents, of the single electrode combinations having an e.m.f. of their own, were next studied. The measurements were made, for each electrode, before and just after the passage of the alternating current. The cells studied were: $Zn \mid ZnCl_2 \mid Hg_2Cl_2 \mid Hg$, $Cd \mid CdCl_2 \mid Hg_2Cl_2 \mid Hg$, and $Zn \mid ZnSO_4 \mid Hg_2SO_4 \mid Hg$, and the results showed that a given cell retains its polarisation longer when an alternating current is used in the external circuit than when the external circuit is simply kept closed. It follows that if a constant value is attributed to the depolarising capacity of each cell, a greater amount of polarisation takes place in the former case than in the latter.

The behaviour of cells in which either one or both of the electrodes are easily polarisable, for example, $Zn \mid ZnSO_4 \mid Pt$ and $Cd \mid ZnSO_4 \mid Hg$, was next studied, as also of cells formed by the combination of two electrolytes. Details of the results obtained are given, but they can only be appreciated by reference to the original paper.
T. S. P